

**MSc Architecture:
Advanced Environmental and Energy
Studies**

GREEN ROOFS FOR URBAN AGRICULTURE

**What is required to support their
implementation in the UK?**

Hanna Waldbaum

January 2008

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UNIVERSITY OF EAST LONDON

School of Computing and Technology

Longbridge Road

DAGENHAM

RM8 2AS

Tel. +44(0)20 8223 3215



Fig.1 Allotments on the roof of a block of flats (Source: The author)

PREFACE

(Words written in italics in this section are explained in the glossary of terms)

This thesis is an investigation into what is required to introduce green roofs for urban agriculture (*agriroofs*) in the UK with the aim to include them in hundreds of new developments that are presently planned for construction in towns and cities around the country. Due to their complexity the provision of *agriroofs* needs to be part of the design of a building from the start.

Agriroofs are accessible *intensive green roofs* which are intended for food production, either as allotments or for commercial production. They form part of *urban agriculture*, a trend that has already started in deprived districts of some cities around the world, and in one island country that was forced by an embargo to become self-sufficient. These experiences have shown that, similar to past allotment acts in the UK, planning policies are needed to ensure *agriroofs* are introduced by law wherever they are needed.

The urgency of this undertaking is prompted by the advent of *peak oil* and climate change that is very likely to put an end to the current, largely unsustainable, ways in which food is produced, processed and distributed around the world at present.

To overcome the reluctance of the establishment to the introduction of new elements in construction it is necessary to present a convincing argument based on documented benefits against expected financial outlay. The arguments in support of *agriroofs* on new construction developments have been investigated using data from research conducted on (the full spectrum of) green roofs in other countries where these have been in use over the past twenty years.

All green roofs share certain characteristics. By replacing traditional roof covers they provide additional insulation, they slow down rain water runoff, provide habitats for *biodiversity*, improve air quality, soften the townscape and have a beneficial effect on the wellbeing of people.

Where obtainable, policies used in some countries have also been studied. Legislation and policies in support of green roofs in this country have been sought, but little was found.

The work of campaigners in the field of green roofs (sometimes called *living roofs*) and in the field of *urban agriculture* has been investigated as well.

Two key areas have been looked at to direct this move towards green roof agriculture: case studies of a few existing projects and the writing of a policy for agriroofs.

Field trips to existing 'edible roof gardens' in the UK and Austria have provided inspiration and the material for case studies, the findings of which have shown that roof agriculture is possible. It became clear that a firm foundation in Local Development Frameworks (LDF) is needed in order to facilitate the introduction of agriroofs - as part of a general green roof policy - in UK cities.

On the basis of these findings a policy proposal has been written and sent out with a questionnaire to a selection of people involved in relevant local government policy making.

The primary research in this thesis consists of the evaluation of the responses received and conclusions drawn, which lead to a revised policy proposal (2nd draft). A final (3rd) version follows after further consultation with policy makers.

This thesis has limited its scope to new-build roofs; therefore retrofitting has been left for further research, as it can also be expected to become an issue in the near future.

To be suitable for the growing of crops, a number of criteria have to be met, such as easy *accessibility*, a minimum depth of substrate, the provision of good drainage and sustainable means of irrigation. Therefore only *semi-intensive* and *intensive* green roofs are being considered for this purpose. The better known, lighter *extensive* green roofs are mostly inaccessible and designed for low-maintenance habitats. They are not suitable for food growing and are therefore not included in the main study of the thesis, although they are referred to, where useful.

Also excluded from the focus of this thesis is the growing of plants in containers, which are traditionally used on roof gardens and terraces and can be used for urban agriculture, but do not fall under the definition of *green roofs*.

ACKNOWLEDGEMENTS

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I am indebted to Dusty Gedge, founder of LivingRoofs.org, for putting me in touch with green roof experts from abroad and for his informative and entertaining talks on the subject.

I am very grateful to the twenty one respondents to my questionnaire, who have given so generously of their time and have provided much food for thought. Their names and occupations are listed in Appendix 11.1.

Special thanks to Cllr. Jon Hooper, who informed and advised me on policy writing; to Geoff Wilson whose website and e-mails have provided me with information on green roofs in Australia, Asia and Canada; to Dave Richards, Lidia Brandstätter, Wilhelm Schlagintweit and Andreas Kraus for sharing their invaluable insider information and for showing me around the impressive green roofs that inspired and encouraged me to write this thesis. Finally I wish to thank all my friends, my fellow AEES students and my family for their much appreciated moral support that helped me throughout the months of writing this thesis.

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LIST OF ABBREVIATIONS

AEES	Advanced Environmental and Energy Studies
CBD	Convention on Biological Diversity
CSH	Code for Sustainable Homes
EFB	European Federation of Green Roof Associations (Europäische Föderation der Bauwerksbegrünungsverbände)
FLL	German Guidelines for Green Roofs (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau)
GHG	Greenhouse Gasses
GRC	The Green Roof Centre
HIP	Home Information Packs
IPCC	Intergovernmental Panel on Climate Change
LCCP	London Climate Change Partnership
LDF	Local Development Framework
NGO	Non-Governmental Organisation
PPS	Planning Policy Statement
RISC	Reading International Solidarity Centre
RUAF	Resource Centres on Urban Agriculture and Food Security
SPD	Supplementary Planning Document
SUDS	Sustainable Drainage Systems

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GLOSSARY OF TERMS

Accessible when referring to green roofs implies that they are built to take normal foot traffic and be used for planting like gardens on the ground; it means that stairs and, if appropriate, lifts give access to them and that they are surrounded by fences or parapet walls for safety.

Agriroof: is short for 'green roof for urban agriculture'; a roof that is specially adapted or purpose built for agricultural use. It is primarily meant for growing vegetables and fruit but can, if appropriate, be used for raising fish, fowl and small farm animals.

Biodiversity: a word coined by W. G Rosen at the 1st planning meeting of the National Forum for Biodiversity in 1985 to mean the totality of biological diversity.

Brown roofs: are sparsely vegetated *living roofs* covered with a substrate that replicates the ground (usually rubble) that had been the habitat for invertebrates and birds, before the building was erected. They are meant to ensure continuity of habitat for biodiversity.

Extensive green roofs are light weight (60 - 150kg/m²) and consist of a thin layer of soil (20 - 100mm) or other growing medium and are planted with low-maintenance plants such as mosses, sedums or grasses; they are not usually accessible except for occasional maintenance work and can be flat or sloping.

Forest gardens, introduced by Robert Hart, are gardens modelled on nature, where vertical layers of planting make optimal use of available space.

Green Roofs are roofs purposely partially or entirely covered with a layer of soil or a similar growing medium and planted with vegetation. Depending on the depth of soil and the amount of

maintenance required they are roughly divided into *extensive*, *intensive* and *semi-intensive* green roofs.

Green roof superstructure is a term used for the system of layers provided above the waterproof roof membrane to support vegetation and wildlife on a roof. It usually consist of a root barrier, a water retaining layer, a drainage layer, a filter layer and topped with the *vegetation layer* consisting of the substrate, soil and planting.

Intensive green roofs are *accessible* gardens on flat roofs and can be planted with a variety of grasses, flowers, vegetables, shrubs and trees. They consist of a complex system of layers with a soil and substrate depth greater than 150mm adding loads between 200 - 500 kg/m² onto the supporting structure. Like gardens at ground level they need a fair degree of care and maintenance and can be used for crop growing.

Living roofs is a collective term used to describe *green* and *brown roofs* that provides habitats for biodiversity.

Organic growing is the traditional way of farming and gardening as it was practiced before the introduction of chemical fertilizers and pesticides.

Peak oil is the point at which oil production starts going into decline; it signifies the end of cheap oil. Seven of eleven OPEC countries have already passed this point (Lucas, Jones, Hynes, 2006)

Permaculture is a holistic model that seeks sustainable solutions in all areas of life from agriculture to people and commerce, guided by the ethics of earth care, people care and fair shares.

Semi-intensive green roofs are a category between *extensive* and *intensive* green roofs, with a soil and substrate depth between 40 and 300 mm on a flat roof. They are mostly planted with grasses and wild herbaceous plants and need only occasional maintenance and are usually accessible. If they are built as accessible roofs and have a substrate depth of 150mm and more,

they can be used for the growing of shallow rooted annual herbs and salads.

Sustainability: "Meeting the needs of the present generation without compromising the ability of future generations to meet their needs." (Brundtland, 1987)

Urban agriculture is the process of growing food crops from small scale allotment and market gardening to large scale urban agriculture within the perimeter of a city or town. This includes the use of walls and roofs of buildings as well as spaces at ground level.

Vegetation layer is the top layer on a green roof that is occupied by the planting, including its roots; it consists of the substrate, topsoil, mulching and planting.

INTRODUCTION

Roughly three percent of the earth's land surface is covered with urban areas according to the 'Global Rural Urban Mapping Project' (Schirber, 2005), yet this is where almost fifty percent of the world's population will be living by 2008 as calculated by the United Nations Population Fund; in countries like Great Britain as many as ninety percent of the population presently concentrate in towns and cities (Viljoen et al, 2005).

The trend to cover relatively small areas of ground with as many buildings and roads as possible for economic reasons while not providing sufficient green spaces has many adverse effects.

People

Urban dwellers suffer from being deprived of contact with nature. Where the ground is sealed off and neither plants nor trees exist to mitigate the pollution created by traffic and buildings, air quality is inferior and the health of the population is affected.

Stress and social tensions are known to be more widespread in areas of high density. Studies have shown the health benefits of living and working in green environments for children as well as adults (Livingstone, 2002d). Psychological effects and subjective feelings of wellbeing when being in contact with nature though less quantifiable are, nonetheless, universally recognised.

Biodiversity

Ecological concerns about endangered species caused by the destruction of their natural habitats have been voiced in many areas. The pollution of air, soil and water and the loss of habitat account for a marked decrease in the number of indigenous wild flowers, invertebrates and birds.

Scientific bodies and voluntary protection societies such as the Royal Society for the Protection of Birds (RSPB) and the World

Wildlife Fund (WWF) are continuously campaigning to raise awareness of these issues in order to influence policy making. The creation of new habitats that link up to become green corridors of vegetation running through built-up areas, and the protection and active encouragement of species (e.g. by providing bat boxes or nesting boxes) can offer effective solutions.

Flooding

Sealed surfaces are unable to absorb water. Cities therefore have to put a high amount of resources into stormwater management. The construction of more and more buildings coupled with the effect of climate change is causing flooding in towns more frequently in recent years. Permeable ground planted with trees and shrubs will naturally absorb a large amount of rainwater before saturation and flooding could occur. Therefore the provision of sufficient permeable ground in the built environment is of paramount importance, in new developments as well as in existing built-up areas.

Food and waste systems causing increased road traffic

The supply of food for the urban population causes a large number of juggernauts to drive in and out of towns on a regular basis, supplying and delivering food to shops and supermarkets. At the other end of the cycle, lorry transport takes care of the collection and redistribution of waste to landfill, recycling or incineration sites. This causes road congestion and air pollution with all its consequences. Food and waste systems as operated at present are therefore major contributors to our carbon footprint. This is a significant problem that the international community has to address in its endeavour to reduce the volume of greenhouse gas emissions (GHG) caused by road traffic.

Urban agriculture

As the cost of fuel escalates there is growing concern for food security in towns and cities. This will ultimately become the main driver for the promotion of urban and peri-urban agriculture.

Vacant spaces on the ground, on roofs and terraces, as well as walls can be adapted or purpose-built for greening and, where appropriate, for use as 'plots' for the growing of food. All

organic waste can be composted, processed and distributed for use locally, creating a healthy life cycle. 'Food miles' are reduced to a minimum, and the application of sustainable organic methods in urban agriculture, apart from bringing valuable health benefits, diminishes our dependency on oil and petrochemicals. The urban population will be able to reconnect with the earth, the source of our daily sustenance.

When the production, processing and marketing of food takes place within the perimeter of the community it supplies, long haul traffic for these goods is eliminated.

It has been estimated that, if efficiently master planned, up to 25% of urban food requirements could realistically be produced locally in the UK climate. (Viljoen et al, 2005). In warmer climates such as in Havana as much as 50% of food is produced within the perimeter of the town. (Community Solutions, 2006)

The greening of buildings

The urban landscape can be positively transformed by turning a town's roofs and walls into green spaces, replacing the land lost to buildings and roads. Interconnected with bridges and ramps, green roofs can recreate a continuous living landscape at roof level, linked via 'green walls' with planting on the ground. The resulting green cities could become more pleasant and healthier environments for people and wildlife. In the wider context, if all urban habitats are greened in this way more carbon will be captured through photosynthesis, thus compensating for some of the emissions presently created by the urbanisation of the landscape.

The Mayor of London's words "*London's most underused asset is just above our heads*" (Ken Livingstone, 12 December 2005) have become a slogan in support of the green roof movement in the UK. Green roofs are already on many national and municipal agendas in countries like Germany, Austria and Switzerland, as a measure to reduce carbon emissions and for biodiversity. Some of the policies and incentives that have been successful in other countries can be used as models for the introduction of similar

measures in the UK. The inclusion of policies for the promotion of urban agriculture will add self-sufficiency to the list of benefits.

The benefits of introducing urban agriculture

The advantages of such policies are numerous: locally grown food travels only a short distance from source to sink, is therefore fresher and more nutritious; people living in towns can grow the food of their choice on allotments and community farms; urban children have the opportunity to learn first hand about growing vegetables and fruit, notably if schools adopt the idea of edible gardens within their grounds. Kitchen scraps, instead of ending up in landfill, as happens at present, can be composted in special containers locally, eliminating the need for transportation to municipal amenities. Most importantly, the physical and mental health of urban dwellers will improve, as became evident in recent years in Cuba (Community Solutions, 2006)

Social and economic benefits will arise from new job opportunities. Neighbourhoods will become communities again, working and celebrating together, getting children and young people involved in the process. The crime rate is bound to diminish in these conditions. Roof gardens and city farms are potential meeting places where people spend time pursuing outdoor activities. Biodiversity is enhanced by the provision of green corridors that run through cities and continue into the surrounding countryside.

This vision is central to the ambition underlying this thesis and forms the basis of the author's quest to determine and draft a relevant policy, to support the political infrastructure required to help achieve these aims. They are, after all, the same aims as set out in government legislation on biodiversity (PPS9, 2005- Biodiversity and Geological Conservation), sustainability and urban development (PPS1, 2005- Delivering Sustainable Development). What is required is both the political will and the correct policy framework to bring this change about.

The need for policy

A legal framework has to be created on a national and local level in the UK. For example an 'Agriroof Policy', as part of a general

green roof policy in Local Development Frameworks, will ensure that roofs are used to their full potential. Agriroofs could also come under allotments or form part of a policy for the general introduction of urban agriculture.

Books and articles about green roofs abound, but there is as yet little mention of roof gardens used specifically for food production. The visionary publication 'Continuous Productive Urban Landscapes' (CPULs) edited and co-written by A.Viljoen (2005) contains much food for thought regarding the introduction of urban agriculture in densely populated cities, using London as a model. However, apart from suggesting the use of flat roofs and plane facades on multi storey car parks for food growing, this work mainly looks at spaces on the ground. Roofs as a source of food are as yet a relatively unexplored idea and it is hoped that this thesis will help to fill this gap in the literature.

To put the need for green roofs for urban agriculture in context, some of the problems the world is facing in the 21st century are highlighted in the following chapter.

1. THE NEED FOR A SOLUTION

In this chapter, the author will present why climate change and fossil fuel depletion are having an increasing impact on our global food supply chain.

1.1 PEAK OIL AND CLIMATE CHANGE

The world is faced with two major interlinked situations: diminishing oil reserves and climate change.

The petrochemicals that permeate every area of modern life are derived from crude oil, which is a finite source that is rapidly diminishing. The easily accessible oil deposits are running out and extraction is becoming more expensive as less accessible sources are tapped. When it takes the energy of a barrel of oil to extract a barrel of oil, production is no longer profitable. The search for new oil fields has brought insufficient results in the last few years.

According to Dr. Colin Campbell (2007) of ASPO the year 1981 marked the time when the world started using more oil than was found (Fig.3). In 2005 for 5 barrels of oil consumed only one barrel was found. Although an exact date of its advent cannot be agreed on, the effect of peak oil is evident through the continuous rise in the cost of oil and everything that depends on it. The theory of *Peak Oil* was developed by M. King Hubbert, the geophysicist who calculated that the rate of oil production follows a bell shaped curve, increasing rapidly and, once it has reached half of its production, rapidly goes into decline (Fig.2).

The Hubbert Curve is used to predict the rate of production from an oil producing region containing many individual wells. He was right in predicting in 1956 that by 1970 America would have reached the maximum crude oil extraction, which it did. (Energy Bulletin, 2007)

HUBBERT CURVE Regional Vs. Individual Wells

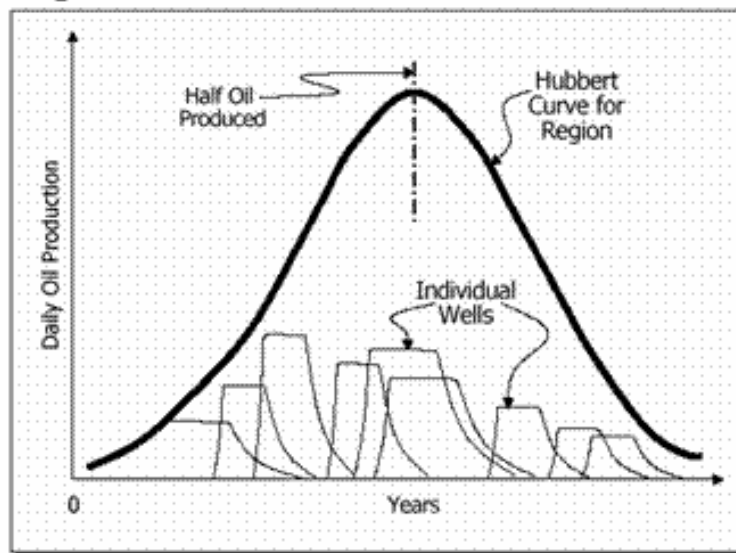


Fig.2 The Hubbert Curve (Source: aspoitalia.net)

After decades of denial the consensus has now been reached that the speed at which the climate is changing globally since the industrial revolution, is due to the increase in greenhouse gas (GHG) emissions caused by our consumption of fossil fuels. Carbon dioxide, nitrous oxide and methane which occur naturally in much lower quantities have increased dramatically through the waste gases emitted by transport, industry, and intensive farming, all of which consume great quantities of oil derivatives. Between 1970 and 2004 GHGs have increased by 70%. Carbon dioxide, the biggest anthropogenic GHG has increased by 80% in that time span. (IPCC, 2007)

At present 43% of total global fuel consumption is from oil; transport is globally 95% dependent on oil and its derivatives. *"For one joule of food consumed in the US around ten joules of fossil fuel energy have been used to produce it"* (Campbell, 2007) This demonstrates the unsustainability of the food industry and the problems it will face in the near future.

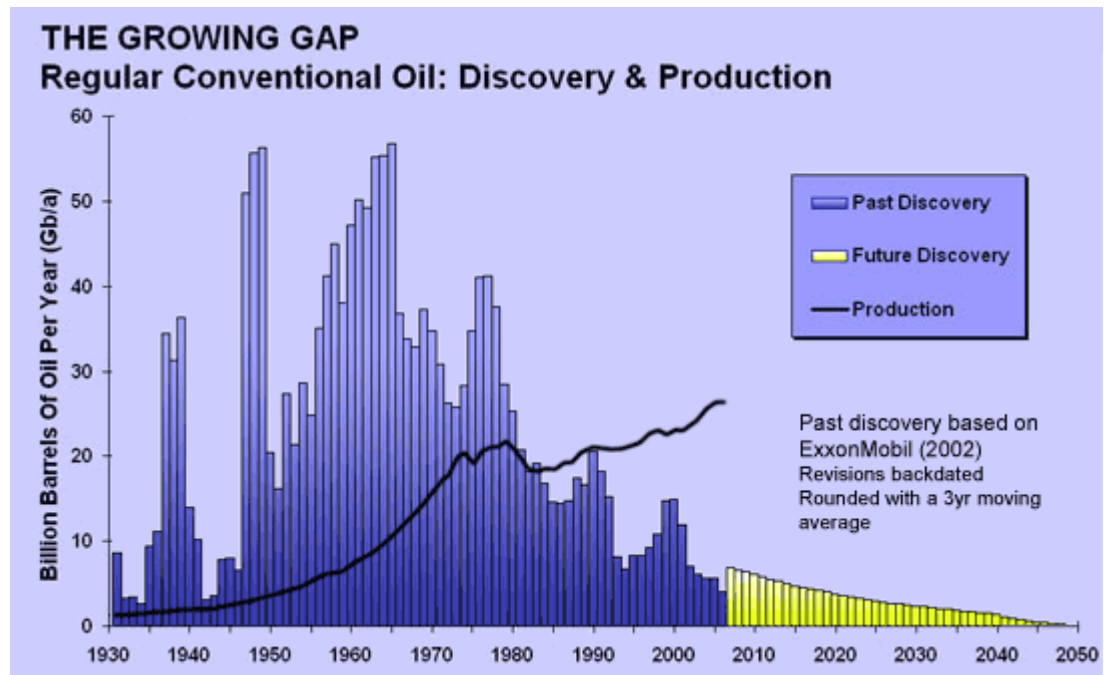


Fig.3 Oil discovery and production

(Source : www.aspo-ireland.org)

Temperatures are steadily rising and weather patterns are changing. The Intergovernmental Panel on Climate Change (IPCC) has recently reiterated that “ *Warming of the climate system is unequivocal as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level*” (IPCC, November 2007).

1995 - 2006 were the warmest years since instrumental records began in 1850 (Fig.4). Temperatures have increased faster in the northern hemisphere and arctic ice is shrinking by 2.7% per decade. (IPCC, 2007)

The Asian and African continents are expected to be hardest hit, and heat waves, droughts, wildfires and flash floods are predicted for Europe as well, if the present trend of anthropogenic Greenhouse Gas emissions continues.

The likely results of this, amongst many others, will be:
- an increased risk of further extinction of species;

- scarcer fresh water supplies;
- decreased yields from rain-fed agriculture; and
- compromised food security.

The international community is obliged to take action on both fronts - GHG emissions and dependency on oil - to avoid catastrophic consequences. National and local governments need to introduce measures to ensure a smooth transition from oil dependency to self-sufficiency. The advent of peak oil and climate change can no longer be ignored.

Changes in temperature, sea level and Northern Hemisphere snow cover

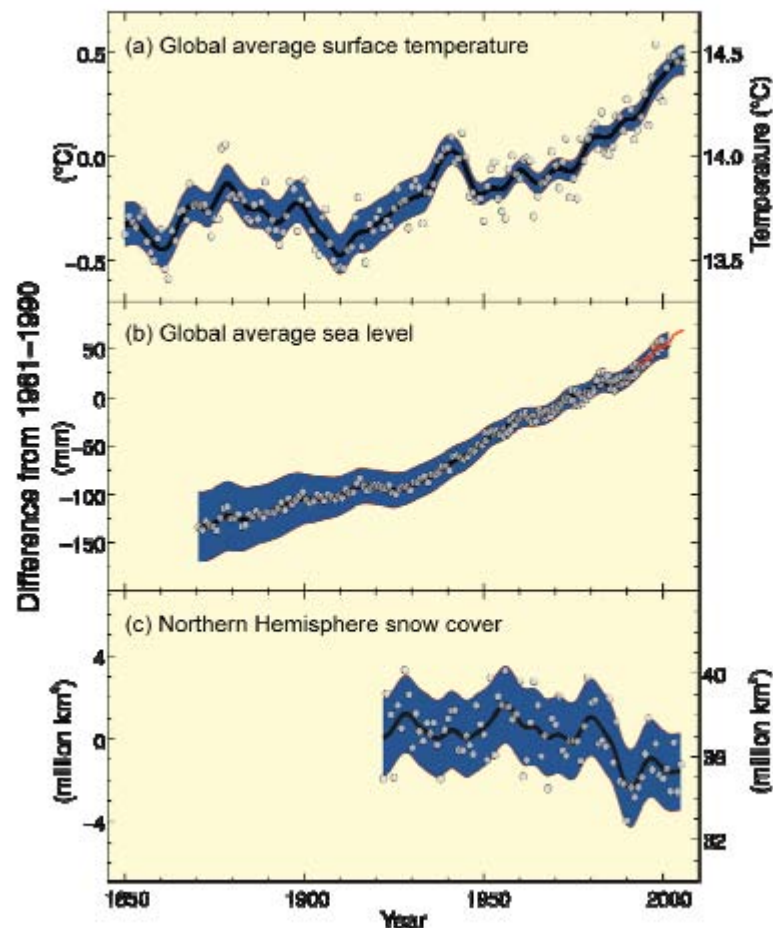


Fig.4 Climate Change 1850 - 2000

(Source :IPCC Synthesis Report 2007)

This has prompted action from the grassroots. In the UK the Transition Towns Initiative - a community process to encourage 'energy descent' (Heinberg 2004, Hopkins 2006) in this transitional period - is gaining interest in many communities. It started in Totnes, Devon in 2006; within one year 28 communities had joined the official list of which 26 are villages and towns in the UK, one Irish community and one Australian. The movement is spreading rapidly as the urgency to act is becoming evident through escalating fuel prices. The concept of Transition Towns has come about as a community response to the need for society and government to take action with regard to peak oil and climate change. The objectives of Transition Towns are:

... *"building community resilience (to mitigate the effects of Peak Oil) and reducing the carbon footprint (to mitigate the effects of Climate Change)"*

in order for communities to be able to sustain themselves when oil dependency is no longer an option. (Transition Town Initiative, 2007)

1.2 THE THREAT TO FOOD SECURITY

The two factors - peak oil and climate change - play a key role in the shaping of our future, particularly in the way food is produced and provided; we need to act collectively and as individuals to ensure our continuous food security, without restricting the ability of other communities to ensure theirs.

The UK fuel crisis in September 2000 illustrated how little it takes to bring the western way of life to a standstill. As petrol stations ran out of fuel, the supply chain inevitably broke down and grocery shelves, usually brimming with food supplies from around the world, were quickly emptied of goods. Whenever a crisis occurs, whether caused by a natural disaster, act of war, national strike or fuel shortage, the supply of essentials such as food, water and electricity are immediately and severely affected. Cities in particular, where it is estimated that half the world's population will be living by 2008, are hardest hit in such

situations. This is due to their complete dependency on supplies being imported from elsewhere, through intricate chains of suppliers, distributors and retailers.

The changeover from food grown naturally, relying on energy from the sun, to the present-day artificial production happened in the 1940s and 1950s with the industrialisation of agriculture (the Green Revolution). The introduction of oil based fertilisers and pesticides brought about an increase in food production, making cheaper food available in the industrialised countries of the world. A few decades on, the down side of the Green Revolution became apparent, as species started to go into decline due to the havoc it created in the eco systems. (Pfeiffer, 2003) It is only in recent years that the warnings of ecologists are being taken seriously worldwide and the protection of species is beginning to be enforced by national and local government policy, such as The Mayor's Biodiversity Strategy for London.

The 1992 UN Earth Summit in Rio de Janeiro raised interest in biodiversity worldwide. In 2002 a '2010 Biodiversity Target' was endorsed at the World Summit of Sustainable Development in Johannesburg, to achieve a reduction in biodiversity loss. The EU intended to take measures "*to halt the loss of biodiversity by 2010*", a target that will not be met, according to The Convention on Biological Diversity's (CBD) website (updated in December 2007).

At the UN Earth Summit in Rio the Convention on Biological Diversity was signed by over 150 nations. Its three major objectives were:

- to conserve biological diversity;
- to use its components in a sustainable way;
- to share fairly and equitably the benefits arising from the use of genetic resources. (CBD, 2007)

The greening of the built environment is an effective means to recreating foraging grounds for species that are threatened with extinction because of loss of habitat to buildings. The wide scale introduction of green roofs is shown to enhance the biodiversity

as is evident from university studies such as those conducted by Stephan Brenneisen (2005) at the University of Zürich.

However, the question of future food security seems not to be addressed on the same scale. The industrialisation of agriculture and the methods employed in farming, e.g. monoculture, have not only destroyed a large number of species, they have also depleted the soil to such an extent that vast amounts of chemicals, most of which are derived from oil, have to be employed to keep up productivity. In some instances the soil is so degraded, that it has to be replaced, such as at Nijar in Southern Spain where soil, "*saturated with chemicals or exhausted by the cycle of three harvests a year...was no longer economical to farm... and new soil had to be brought in.*" (Lawrence, 2004 a)

Other examples of food dependency on oil are the current intensive chicken farming and processing methods. The birds are transported by juggernauts from their cramped, artificial, energy intensive farming environment to the slaughterhouse, where sophisticated machinery electrocutes, plucks and slices them into sections which are then separated for packaging or processing. This is usually done at another factory meaning more transportation by road or by air. In addition cheaper, 'special offer' chicken meat is flown in from Thailand or Brazil, processed in the Netherlands, before landing on British supermarket shelves. (Lawrence, 2004c)

Leaving aside the worrying fact that the origin of the meat is often no longer traceable, the amount of food miles and energy involved in taking the meat from the farm to the table is unsustainable. The same applies to imported fruit and vegetables. Some supermarket vegetables imported from Africa "*...will typically have travelled between 4,000 and 6,000 miles to reach us*". (Lawrence, 2004 b)

McLaughlin (2000) calculated the agricultural energy consumption per person per annum in the US in 1994 to be the equivalent of 400 gallons of oil. 31% of this energy is used for the manufacture of inorganic fertilisers, 16% for transportation, 5%

for pesticide production, 19% for the operation of field machinery and the remaining 29% for raising livestock, irrigation, crop drying, etc. In addition fossil fuels are used for refrigeration, packaging and transport to retail outlets. Therefore ..."*In a very real sense we are literally eating fossil fuels*". (Pfeiffer, 2003)

The transportation of food from producer to distributor, from there to markets and shops and finally to the consumer's table contributes to the congestion of roads and the pollution of the environment. The growing of food in close proximity to the consumer conversely, eliminates the need for mechanical transport and enhances ambient air quality.

Continuous food security is a major factor in the smooth transition from present-day dependency on oil for food production and transportation to local self-sufficiency. There are many actions that will be required to increase our food security at home and reduce our dependence on other communities to supply our needs. These actions will range from consumer habits, to conventional farming at a large scale.

The aim of this thesis is to propose one possible solution to supplement this range of approaches that are needed, to help ensure that food is available in the built environment when the oil runs out. Urban food production could be the answer to many of the issues raised in this chapter.

2. URBAN FOOD PRODUCTION

Prompted by high prices and the dubious quality of food currently available in towns, urban food production has become the subject for a number of NGOs as well as some local government bodies around the world. In Berlin a conference was convened in March 2006 by the Senate Department for Urban Development to discuss the state of urban agriculture in the city. It was found that it had fallen into decline since the unification of Germany in 1989, and was in need of revival. The participants were the public parks department and agribusiness representatives.

A study conducted at San Francisco State University (Pinderhughes et al, 2000) has found that urban agriculture is increasingly being practiced in parts of Asia, Africa as well as in both South and North America ...*"in yards, on rooftops and balconies, along roadsides, and on vacant urban land"*. However, *"Cuba is the only country in the world that has developed an extensive state supported infrastructure to support urban food production and urban growers."*

Food shortages are the cause and the driving force behind the growing interest in urban agriculture.

The Resource Centres on Urban Agriculture and Food Security (RUAF) is a global network that has been active since 1999, working towards implementing an international programme for urban agriculture (UA) and food security as a means to alleviate poverty among disadvantaged urban groups. It informs, educates, advises and helps initiate urban agriculture projects in Asia, Africa and South America. RUAF is actively involved in helping local policy formulation and action planning. The reuse of urban waste and grey water in UA is one of their areas of interest.

And Geoff Wilson (2006a) convenor of 'Green Roofs for Healthy Australian Cities' draws attention to the fact that *"the more affluent nations also need urban agriculture for a better diet and life style."*

One of the Transition Town initiatives is to ensure local food security by organising food growing projects in the community with the aim to becoming largely self-sustaining.

Transition Town Brixton, South London launched a local food-growing project called ABUNDANCE in December 2007 (a fitting acronym that stands for 'Activating Barren Urban Niches for a Daring Agricultural Network of Creativity and Endeavour'). This is a joint venture between University College London (UCL), Transition Town Brixton campaigners and the residents associations from a dozen housing estates that have expressed interest in growing food on the neglected green spaces around their blocks, on balconies, window sills and roof tops. This, like a number of other food growing projects is a voluntary initiative, in response to the present state of the food market. Food scares, escalating food prices, the use of chemicals in food production have driven people to want to take control over the food they consume. There is growing awareness of a need to become independent of fossil fuels in food cultivation and distribution.

The Designs Of The Times (DOTT) 07 regional initiative includes an urban farming project in Middlesbrough, North Yorkshire, that was started by Groundwork South Tees at the beginning of 2007. Vegetables were grown throughout the season in previously unused spaces in the city in homes, streets, school yards and community centres. They were harvested and shared in the town by food co-ops, supplied an open organic restaurant and culminated in a 'Soil to Plate' harvest festival in the centre of town in September. The success of this project prompted the town's council to expand the urban food growing project in the coming year as part of its community regeneration programme. (McCourt, 2007)

This demonstrates how a small community can bring about positive change which has the potential to be adopted by the local authority to the benefit of the wider community.

These are sustainable community projects, using the skills of volunteers, exchanging experiences, sharing the produce, celebrating the harvest.

2.1 ROOF SPACE FOR URBAN FOOD PRODUCTION **(AGRIROOFS)**

As land is at a premium in towns and cities, there is an acute shortage of green spaces at ground level, except where planning laws enforce their provision. Since vegetation is essential for a healthy environment - which our cities endeavour to become - the greening of buildings can compensate for the loss of greenery on the ground, although ideally conserving existing green space in the first instance must be the priority. Moreover, as flat roofs are now the norm on many developments, these are the obvious spaces to use for this purpose. With urban food production in mind, such roofs should be constructed to meet the requirements needed for their use as agricultural space, where appropriate. It is important that the future demand for agricultural space in the urban environment is understood by town planners and that the relevant policies are negotiated and ratified now.

The benefits arising from covering roofs with vegetation are already well documented. Flat roofs on all new government, commercial and industrial buildings, warehouses, parking garages, restaurants, housing estates and schools have the potential to become the agriroofs of the future.

Small scale projects of this kind already exist, many of them in Austria, Switzerland and Germany; the technology for intensive green roofs is available; and the tough standards for green roof construction and maintenance used in other countries - such as the FLL in Germany - can also be applied in the UK.

The next step beyond this would then be to promote the retrofitting of green roofs on existing buildings, so that every family can have access to space for food growing. Some municipalities in other countries have already introduced steps to

encourage the retrofitting of green roofs. For example in Vienna grants of up to 2200 Euros have been available since 2003 for retrofitting, while green roofs are now compulsory on all new buildings with flat roofs over 100m².

The greening of roofs and walls with perennial vegetation has taken hold in a number of countries. Because of their complex nature, green roofs designed for urban agriculture incur higher initial capital costs, firstly for the additional load bearing down on the structure and secondly for the specialised green roof superstructure. It must be borne in mind that food security is the principal driver for this undertaking and that food grown locally brings many benefits:

- freshness of produce;
- traceability of origin;
- choice over growing methods (e.g. organic / low pesticide, no-dig, permaculture);
- reduced transport - reducing carbon emissions;
- job opportunities;
- educational, teaching children (and adults) how to grow food;
- recreational, as it provides exercise outdoors;
- social, as sharing in the community and co-operation follow naturally.

Twenty years experience in countries like Germany, Austria and Switzerland and studies conducted in Canada prove that green roofs bring a number of benefits to the environment:

- enhanced biodiversity (Brenneisen, 2005);
- nature conservation (protecting species faced with extinction);
- creation of microclimates (Brenneisen, 2005);
- reduction of the urban heat island effect through evapo-transpiration (Banting et al, 2005)
- acoustic insulation;
- thermal insulation (reducing need for heating and cooling);
- reduction of rainwater runoff through absorption (FLL.2002)
- slowing down of stormwater runoff through absorption (PSU, no date);
- shielding from electrosmog (Minke, 2001).

2.2 QUANTIFIABLE SAVINGS

Energy savings

Part L2B: 'Conservation of fuel and power in existing buildings other than dwellings' of the Building Regulations (2006) requires a roof to have an average U-value of no more than $0.25 \text{ W/m}^2\text{K}$ and a limiting U-value of $0.35 \text{ W/m}^2\text{K}$. The same values are required for flat roofs in existing dwellings. There are as yet no provisions in the Building Regulations regarding roofs covered with a continuous layer of soil or substrate and planting (i.e. green or brown roofs) but the required values can equally be achieved by green roofs (CIRIA C644, 2007). Though no precise data are available it can be stated empirically that a roof garden constitutes an additional thermal mass which therefore lowers the thermal transmittance (U-value) of an existing roof.

The Green Roof Technology Study conducted in Toronto concluded that, if 5 000 ha of available flat roofs - that is 8% of the total area of Toronto - would be covered with green roofs the ambient temperature would be reduced by $0.5 - 2.0^\circ\text{C}$, depending on time of year. Thus the energy used for cooling due to the urban heat island effect would be reduced by an equivalent of 4.15 kWh/m^2 of green roof per year. Other benefits that amount to substantial savings would come from the reduction in storm water flow and from air quality improvement. (Banting, 2005)

However, there is some debate among green roof proponents regarding the thermal properties of a green roof because of the fluctuation in water content. Thermal insulation can be cooling or warming. It acts as a barrier between two spaces with different temperatures. A humid or wet layer of soil and planting has a cooling effect on the space it covers, due to evaporation of soil and transpiration of plants and because it absorbs the heat of the sun. There is a long standing tradition in countries like Austria, parts of Germany and Switzerland where wine cellars are covered with earth and grass (Fig.5).



Fig.5 Traditional Austrian wine cellars: keeping cool under green roofs.
(Source: The author)

In order to have a warming effect, insulation has to be dry. On a green roof this function has to be fulfilled by an insulation layer placed under the superstructure of the green roof and protected by sound water proofing which in turn is overlaid with an impenetrable root barrier.

Some local planning authorities in the UK, such as Brighton and Hove, Sheffield and Kirklees are planning to include green roofs as sustainability measures in their SPDs (e.g. as part of SUDS and for their energy saving thermal properties as required by Part L of the Building Regulations 2006). However, the strongest driver amongst those promoting green roofs at this stage appears to be biodiversity, in itself a considerable and important benefit.

Surface water attenuation

Portland and Seattle in the US and Stuttgart, Cologne and Münster in Germany are examples of cities that offer up to 80%

reduced sewage tax rates to occupiers of buildings with green roofs.

The volume of water retained by a green roof depends on its substrate depth and additional water retentive materials used in the superstructure such as reservoir boards and fleeces.

According to the FLL (2008a) an intensive green roof with 250-500mm substrate will retain an average of 70% water p.a.

Substrates over 500mm retain more than 90%, while the figures for extensive green roofs with substrates of 20-200 mm are between 40-60% water retention.

In addition, stormwater is slowed down considerably by green roofs as is demonstrated by a study conducted over 7 days at the Green Roof Research Centre at Penn State University (Fig.6).

Liam Foster (2007) gave a presentation at the Architect's Journal Green Roof Conference, London on the cost benefits resulting from reduced needs for below-ground attenuation structures. He listed three characteristics of green roofs to this effect: storing water, delaying water, losing water (through evapo-transpiration). He also pointed at PPS 25 - Development and Flood Risk DCLG (2006) that imposes tougher requirements to limit surface water from development sites.

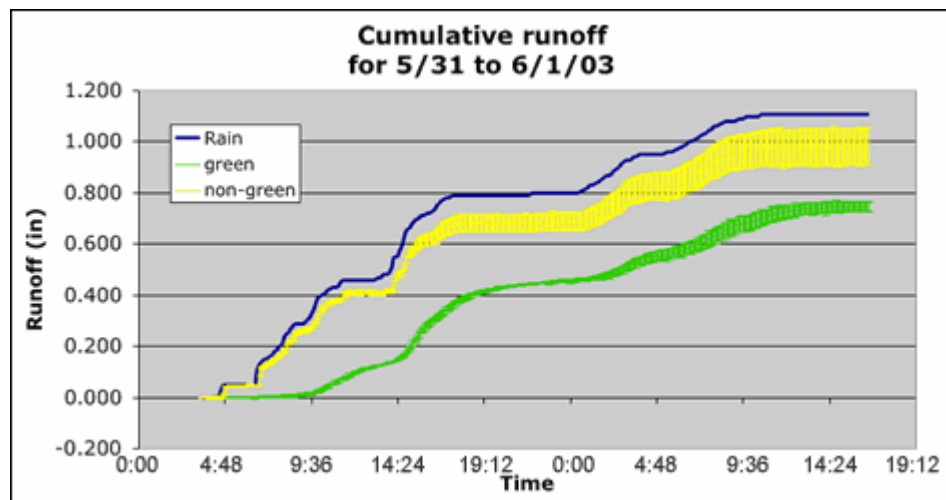


Fig.6 Cumulative rainwater runoff
(Source: PSU Green Roof Research Centre)

2.3 INTENSIVE GREEN ROOFS

To be suitable for food production the roofs have to be executed as accessible intensive green roofs and be provided with the necessary infrastructure and safety measures according to building regulations. Maintenance and liability issues also need to be addressed. The focus for food growing is on *intensive* green roofs, leaving out *extensive* green roofs, which have only a thin layer of vegetation intended for low maintenance, are not accessible, and therefore do not come under the scope of this thesis, although as stated above, they have their own extremely important role to play in improving urban environments at many levels.

Intensive green roofs are accessible gardens on flat roofs up to 3° maximum slope, that can be planted with a variety of grasses, flowers, vegetables, shrubs and trees. They consist of a complex system of layers with a soil and substrate depth greater than 150mm adding loads between 200 - 500kg/m² onto the supporting structure. Like gardens at ground level they need a fair degree of care and maintenance and are suitable for crop growing.

For the purpose of food production 300mm has been found to be adequate (see case study Sargfabrik, Vienna). Therefore this depth is suggested in the first draft of the policy proposal as a minimum depth and should be included in the Supplementary Planning Document in the final policy.

The Guidance for the Planning, Execution and Upkeep of Green Roof Sites - FLL (2002), available in English, gives exact data for standards of execution and upkeep of all types of green roofs and CIRIA have recently published guidance book C644 (2007) 'Building Greener' with comprehensive information about green roofs. Manuals are also available from manufacturers / installers (e.g. Bauder, Alwitra, Alumasc, Anderson Monarflex) giving details of the layered superstructure.

Intensive green roofs must be built to be accessible and safe to use. Therefore access onto the roof must be by permanent internal access (via stairs, ramps or lifts), and balustrades or

parapet walls must be in place at safe heights (to prevent falls and items being dropped onto people below) and must conform to the Health and Safety at Work Act 1974, Building Regulations Part K (2000) and the Construction (Design and Management) Regulations 2007. These are obviously the same standards as are applied to all accessible roof spaces.

Fig.7. shows a section through a typical intensive green roof. The layers above the waterproof membrane are the components of the green roof superstructure.

The Root Barrier

This is a seamless mechanical barrier that either acts as waterproofing and root barrier in one or is laid on top of a waterproof membrane that is not root resistant (as in Fig.7). The root barrier together with the waterproof membrane forms the layer that protects the building from damage that could otherwise be caused by water and vegetation.

Reservoir and Drainage Boards

The reservoir and drainage board layer is a water storage and distribution device. It consists of a continuous layer of plastic boards with evenly distributed extrusions of typically between 25 and 60mm depth which act as water reservoirs. Once the water reaches the top of the board it overflows through drainage holes and is channelled into the underlying roof drainage system. This layer stores water even when placed on a slope and prevents the roots from drying out as well as from getting water logged. During rainfall the boards first fill to capacity with water before channelling the surplus into the rainwater collection system. On average 60% of the rain falling on a green roof is absorbed by it, thus reducing the need for irrigation of the roof, and impacting beneficially on the threat of local flooding. (Hynes, 2007)

Reservoir Fleece and Filter Fleece

The reservoir fleece is loosely placed above the root barrier which it protects from mechanical damage, especially during building works. With the reservoir and drainage board placed on top it becomes part of the water storage and drainage system.

The filter fleece is laid on top of the drainage board and prevents silt and plant solids from clogging up the water storage and drainage system.

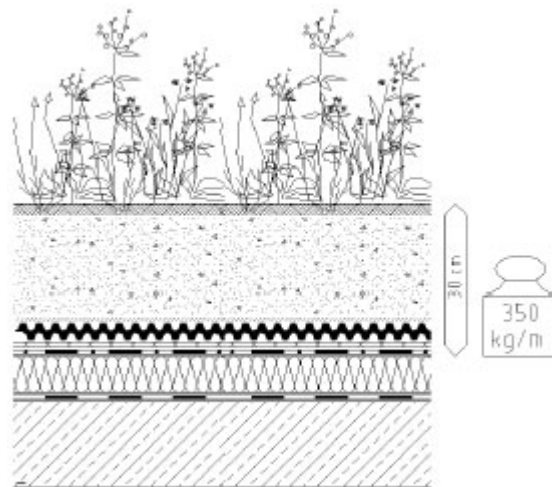
Fleeces are water permeable and have four different applications:

- as separators between chemically incompatible materials;
- as filters to inhibit leaching of fine particles;
- as protection, guarding the underlying roof membrane from damage;
- to absorb water and act as reservoir.

A fleece can also combine two functions, for example water storage and protection in one.

Substrate and soil

Above the filter fleece the substrate is distributed to the required depth, before the topsoil is finally applied. The substrate (e.g. Bauder Intensive Substrate) is a mixture of recycled building material (such as crushed brick), pumice, expanded clay, and about 25% organic matter. The substrate is a lightweight growing medium, tailored to optimise conditions for the vegetation while minimising the overall weight of the green roof. It is an advantage of a green roof that the soil can be mixed to order and with the right pH. According to Shepherd (2007a) the pH should ideally be between 6.5 - 6.8. No chemical contamination must be present. The FLL for example prescribes strict standards for the testing of substrates used on green roofs and it is especially important to observe these where edible plants are to be grown.



- Vegetation (Grasses-Shrubs-Small trees)
- Soil
- Substrate
- Filter Fleece
- Drainage and Reservoir Board
- Reservoir Fleece
- Root Barrier
- Waterproof Membrane
- Thermal Insulation
- Vapour Control Layer
- Structural Roof Deck

Fig.7 Section through a typical intensive green roof

(Source: ALWITRA roofing products (<http://www.icb.uk.com>))

2.4 SUSTAINABLE GROWING METHODS FOR AGRIROOFS

Local conditions will determine what can be grown on a roof. Shelter against high winds may have to be provided in exposed conditions. Close planting and maximum ground covering (with plants or mulching) will ensure moisture is retained in the soil. Companion planting will enhance the quality of some plants, and a cottage garden mixture of vegetables, fruits, herbs and flowers works to advantage. Monocultures must be avoided as they encourage pests and disease. (Shepherd 2007; Hart 2001)

The number of edible plant species that can be grown in 300mm substrate is substantial. The list of edible and medicinal plants grown on the RISC roof for example, names over 140 varieties.

The following is a list of common vegetables that can be grown on agriroofs, depending on local climatic conditions (it is by no means comprehensive): beans, peas, peppers, tomatoes, sweet corn, sunflower, cucumber, pumpkin, squash, fennel, garlic, onion, leek, carrot, turnip, radish, parsnip, Brussels sprouts, broccoli, cauliflower, cabbage, lettuce, spinach, marjoram, thyme, basil, oregano, parsley, chives, chervil, rosemary, sage, strawberries, raspberries, gooseberries, currants, grapes and small fruit trees. Potatoes are best container grown, whereby soil is added as the plant grows. (The container can be made up of tyres that are successively stacked and filled with soil.) Trees may need securing, if exposed to strong winds. Their height is naturally limited by the given root restriction, such as in Bonsai trees. Dwarf fruit tree varieties are a suitable choice but blackberries, buddleias and similarly virulent plants should be avoided.

The introduction of agriroofs must be supported by instruction of suitable growing methods that are not labour intensive, do not use agrochemicals, and manage resources sustainably. Cities produce large amounts of kitchen waste that can be composted for local use. Wastewater preferably processed through biotechnology rather than chemical treatment can be used for irrigation. Rainwater can be harvested and pumped onto the roof by on-site renewable energy. Hydroponics, nocturnal drip-irrigation, mulching and zero tillage (no-dig) are all common horticultural and agricultural methods that reduce water needs and can be applied on green roofs.

Roof irrigation is best activated during the night when evaporation is minimal and electricity cheapest. Water harvested from surrounding pitched roofs or processed grey water from the building's baths and sinks can be used for the irrigation of a roof garden. This reduces the volume of mains water use and relieves the sewage system. In the rainy season the rainwater is first absorbed by the soil and planting in an

intensive roof and only after saturation is reached does it run off into the storm water system.

The composting of all organic waste in rat proof containers (e.g. wormeries) within the locality will solve some of the waste removal problems for the municipality and provide organic compost for local green roofs and gardens.

Permaculture and Forest Gardening are two tried and tested methods suitable for application on green roofs.

Permaculture

Permaculture is a method that offers practical solutions for sustainable food production in a variety of agricultural settings, especially in the case of adverse or unusual circumstances, hence its relevance in urban settings. With its basic ethics of Earth Care, People Care and Fair Shares its application in the context of urban agriculture is of great benefit for consumers as well as for the environment. Permaculture can be applied in all areas of human activity, encompassing all spheres of life manipulated by man. It has become an important element of the Transition Town concept.

The concept of Permaculture was introduced in the mid 1970s by Australians Bill Mollison and David Holmgren, who maintained that the Australian interior which is largely a desert can be turned into permanent agricultural land, hence the name permaculture. As is often the case with inventions, it soon transpired that similar principles were simultaneously developed in different parts of the world. In England Robert Hart developed the Forest Garden, in Austria Sepp Holzer created a tropical garden at 1000m altitude in the Alps using similar methods. Friedensreich Hundertwasser was the first to introduce these ideas into the built environment, first through his paintings and writings and later through his architectural designs.

A prime example of the successful application of permaculture on a large scale is the urban agriculture introduced in Cuba. This took place over a period of years in the 1990s when the country

was faced with starvation in light of the dissolution of the Soviet Bloc that had previously supplied the country with food, agrochemicals and fuel. At the same time, the US Government created an embargo reducing imports and exports from the country almost to nothing and forcing Cuba to become self-reliant in food. (Community Solutions, 2006)

Permaculture uses nature as its teacher and finds solutions that harmonise with nature laws. By planting species in symbiotic combinations infestation can be largely avoided and by adding organic compost and mulching to the soil the need for artificial fertilizers becomes obsolete. (Whitefield, 2004)

The devastation that the last 200 years of industrial progress have created on our planet can only be halted and reversed by careful and considerate work based on principles that honour the Earth and its entire people.

Forest Gardening

Forest Gardening is a concept which Robert Hart developed in the 1970s at his small farm at Wenlock Edge in Shropshire. His book 'Forest Gardening' subtitled 'Rediscovering Nature & Community in a Post - Industrial Age' gives instructions for the creation of edible gardens modelled on a forest eco system. In the foreword to the 2001 edition Herbert Girardet calls them "*forests modified to suit human needs*".

In a forest garden the planting is done in layers or storeys and plants are placed where they best harmonise with each other (companion planting). The available space is used to capacity and ground cover protects the soil from drying out. Hence it is ideally suited for roof top conditions, where space is limited and exposure to sun and wind could cause the soil to dry out.

A forest garden, as suggested by Robert Hart (1996) has seven 'storeys':

1. The tall tree 'Canopy' of standard or half-standard fruit trees;
2. The 'Low-tree layer' of dwarf fruit and nut trees;
3. The 'Shrub layer' of bush fruits / shrubs;

4. The 'Herbaceous layer' of herbs and perennial vegetables;
5. The 'Ground-cover layer' of creeping plants;
6. The 'Rhizosphere' of shade-tolerant and winter root-plants;
7. The 'Vertical layer' of climbing and trailing plants.

The roof garden at RISC followed this model. (Case Study 3.1 RISC, Reading)

Diversity and symbiosis are keynotes of forest gardening. Through diversity of plant species the proliferation of pests is minimised and the symbiosis that exists naturally between certain companion plants ensures mutual help and additional protection. The planting is mainly perennial or self-seeding. Careful planning using these principles results in a reduction in the amount of work needed; in addition the use of pesticides becomes unnecessary. This makes the forest garden a healthy and ideal model for an edible roof garden.

New sustainable technologies

A promising 'Green Roof Self-Sufficient Fresh Food Production Pilot Project' that is presently being conducted at Central Queensland University. It is working on combining food waste recycling and air moisture harvesting on city roofs with food production using hydroponics, aquaponics and aeroponics. The idea is to cut out transport altogether by placing these micro-farms on the roofs of shopping malls in the centre of towns, recycling the waste using vermiculture, and delivering the fresh produce to local restaurants. These roof farms are envisaged for growing vegetables and fruit as well as raising fish and crustaceans in tanks. (Wilson, 2006b)

Data are not yet available for publication but the results should be interesting in their contribution to this debate.

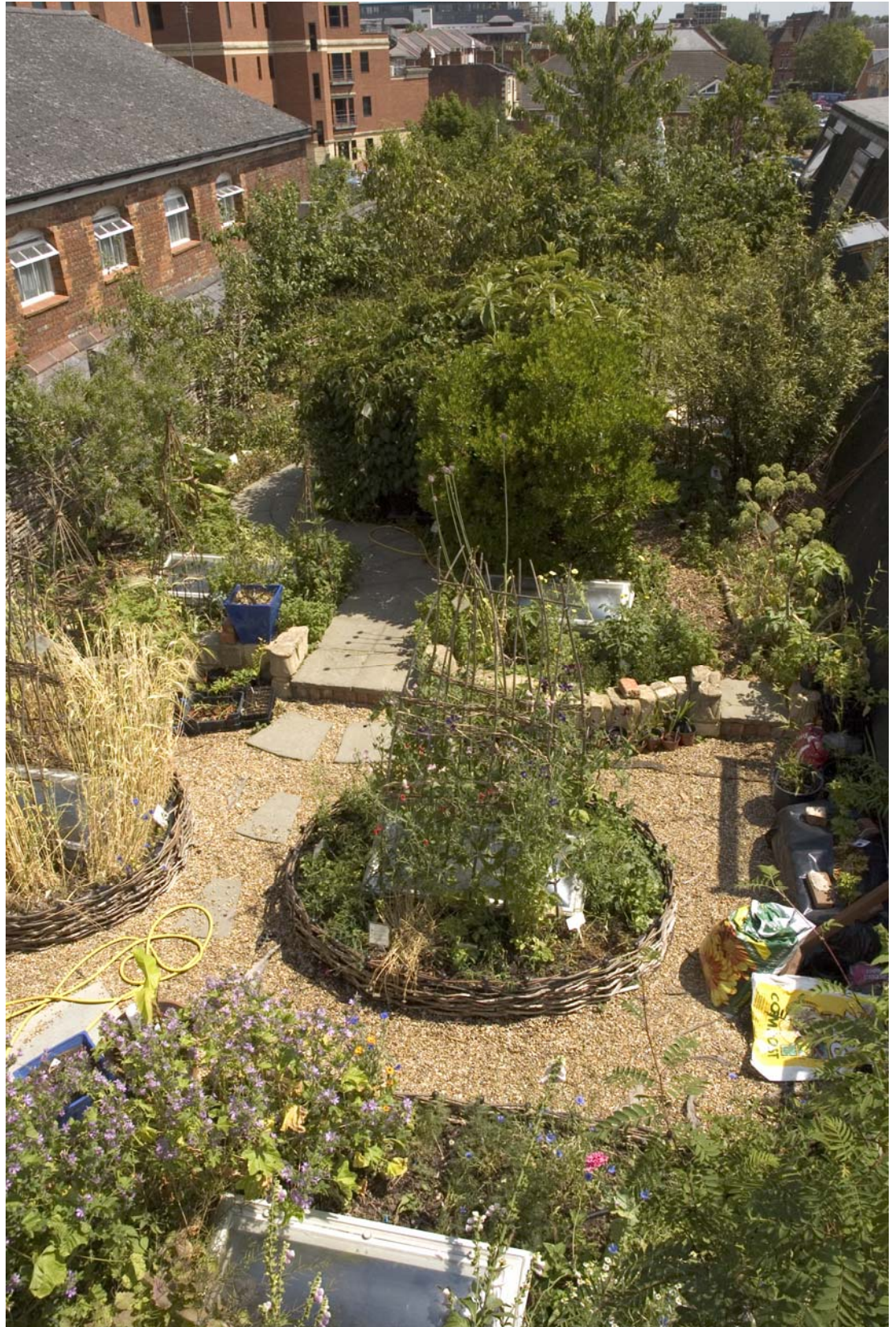


Fig.8 RISC Edible Roof Garden in 2006 (Courtesy Dave Richards)

3. CASE STUDIES

The following case studies of existing edible roof gardens from abroad and the UK serve to illustrate that food can be grown successfully on urban roofs. These are as yet small scale isolated cases, based on private initiatives.

3.1 CASE STUDY 1

**The Edible Roof Garden at the
Reading International Solidarity Centre (RISC)**
(Site visit and interview with Dave Richards 12 June 2007)

RISC is described on its website as a development education centre dedicated to "*promoting action for sustainable development, equality and social justice*". The author has chosen its roof garden as an example of what can be achieved in an established urban environment with minor structural adjustments, careful planning and skilful execution.

An existing flat roof measuring 6 x 32 metres, situated in the heart of an English town has been turned into a lush and productive 'forest garden'. Now in its 6th year, the garden was established primarily for educational purposes

"to raise awareness of global issues, including sustainable development and the economic and historical importance of plants".

The flat roof at RISC had fallen into disrepair and revealed itself to an imaginative member as a potential garden, two floors above street level, sheltered on three sides by the walls of neighbouring buildings. The creation of a roof garden proved to be the solution to a number of problems that needed to be solved: leaky water proofing, non-existent sound proofing and insufficient thermal insulation.

The RISC roof was refurbished in 2001 and planting began in 2002 with a variety of edible plants. The photographs of its

construction provide a useful guide to the retrofitting of intensive green roofs (see Appendix 11.5). About 140 edible species including 3-5m high fruit trees, shrubs, climbers and herbs are now growing on an area of just 200 m² and providing some of the food for the restaurant kitchen and an 'edible classroom' for educational purposes. Being grown locally, the fruit and herbs are harvested when they are needed, and taken down two flights of stairs to the restaurant kitchen, thereby retaining all freshness and nutritional quality.

At the end of the day kitchen scraps are returned to the roof and mixed with cardboard and waste paper from the office for composting. This reduces the amount of waste normally collected and transported to municipal amenity sites, often ending up in landfill and emitting the greenhouse gas methane.

The RISC website's section on the roof garden (www.risc.org.uk/garden), explains that

"A forest garden takes two years to establish, after which it becomes self-perpetuating, self-fertilizing,...self-weed suppressing, self-pollinating, self-healing, and highly resistant to pests and diseases."

The maintenance work needed once the garden is established consists of pruning and controlling the growth of plants and mulching with compost in the autumn.

The roof garden has survived the droughts of recent summers by storing rainwater harvested from surrounding roofs which is filtered, and fed into a finely laid out drip feed irrigation system that is activated at night during dry spells. Leaflets available from RISC on "beating the drought" and "water harvesting" give advice on low-water gardening, elaborating on the main points which are:

- collect all suitable sources of water;
- water economically;
- retain moisture in the soil;
- protect soil and plants from the sun.

The electricity for the irrigation system is provided by a small roof mounted 70W wind turbine and a small array of photovoltaic

panels situated above the small greenhouse at one end of the roof garden.

The available space is used to its maximum. The surrounding walls and fences are covered with cordon and fan-trained fruit trees and climbing vines. The methodical creation of 'plant communities', chosen for their ability to work in symbiosis, and the diversity of species planted eliminates the need for fertilisers and pesticides. The close planting has the effect of covering most of the ground, in the way nature does in the wild. This conserves water by inhibiting evaporation from the soil because of plant shading.

The project behind this roof garden is called 'Growing our Futures' and is

"a statement about potentials of working with nature in creative partnership, to create quality living spaces, providing food and resources for people, supporting bio-diversity in our own back yards".

Naturally such an oasis in a brick and mortar environment provides a habitat for insects and birds, improves air quality, and creates its own micro climate.

In addition the layers of substrate, soil (300mm deep on average) and planting increase the thermal resistance and the acoustic quality of the roof, which covers a hall often used for noisy activities by community groups.

The roof garden is used for educational and recreational activities and provides a pleasant outdoor space for the occupants of the building and those using its conference facilities and meeting rooms.

RISC edible roof garden is probably the first attempt in the UK to plant a forest garden on a roof. The experience gleaned from this small roof garden - with a soil depth of only 300mm - during the 6 years since it was first created, serves as a valuable source of information on all aspects of roof food growing and gardening in Southern Britain. It has been particularly useful to discover which plants have thrived and which have struggled in a relatively

shallow substrate during drought conditions. Local geographic and geological conditions will dictate to some extent what can be grown in each location. Permaculture principles can then be applied to optimise the yield from a roof garden without the use of fertilisers or pesticides.

3.2 CASE STUDY 2

Medicinal herb garden on the roof of Aspern Pharmacy, Vienna 'Apotheke zum Löwen von Aspern'

(Site visit and interview with Dr. Wilhelm Schlagintweit on 10th July 2007)

This award winning purpose built pharmacy, designed by ARTEC in 2003 is situated on a busy main road on the outskirts of Vienna.

It has been chosen as a case study because of its unusual medicinal herb garden which is situated above the open plan pharmacy and dispensary.



Fig.9 Aspern Pharmacy, medicinal roof garden
(Courtesy Dr. Wilhelm Schlagintweit)

The herb garden by Jakob Fina follows the formal pattern of the medieval herb gardens of the Abbey of Seligenstadt, Germany and that of St Gall, Switzerland. The purpose of this roof garden is educational for the public as well as practical for the herbal and homeopathic department of the pharmacy. It is open to the public in conjunction with thematic exhibitions and lectures and is frequently visited by schools.

This intensive green roof is 15m wide and 16m long (240m²). The depth of soil plus substrate is 750mm. The herb garden covers the full width of the pharmacy building and is surrounded on three sides by a 142 cm high parapet that creates the atmosphere of a walled garden, protecting it from the wind. It is laid out as a formal herb garden, strictly divided into 13 thematic beds separated by paths made from timber decking. It is planted with around 430 different medicinal plants; the themes refer to parts of the human anatomy with associated medical conditions and the curative herbs. Timber decking was chosen to make it accessible for groups of visitors.

Aspern pharmacy has appeared in many international journals, including the Architects' Journal (No.20, Vol.222, London 2005). It has gained in popularity both locally and with visitors from further afield and the unique herb garden on its roof attracts much attention. It is a good example of a multifunctional green roof: educational, recreational and useful for its medicinal plants that can be processed on the premises. It is a small scale example which shows that a roof can be turned into a productive garden for commercial purposes; it can serve as a model for larger, industrial scale green roofs above manufacturing premises.

3.3 CASE STUDY 3

Rooftop allotments at 'Sargfabrik', Vienna.

(Site visits and interviews December 2006, February 2007 and July 2007 with Lidia Brandstätter and architect Franz Sumnitsch, BKK3)



Fig.10 'Sargfabrik' Vienna, roof allotments (Source: The author)

'Sargfabrik' is an award winning housing complex and community centre that was built between 1994 and 1996 on the grounds of a derelict 19th century coffin factory in Vienna's 14th district. It is a jointly owned and shared co-housing association with facilities that are open to the wider community, including a swimming pool, a cafe, a nursery school, a seminar room and a 300 seat concert hall that has become a centre of cultural excellence. The 112 apartments provide spacious accommodation for around 150 adults and 60 children at present.

The buildings contain many sustainable features: they are well insulated; the heating for the swimming pool is provided by renewable energy from the PV panels; solar panels provide most of the hot water for residents; composting of all kitchen waste is done on site; large windows overlooking planted court yards allow for maximum daylight use.

It was chosen as a case study for its roof allotments above the main residential building. One third of this intensive green roof is used as allotments which contain fruit trees, soft fruit bushes and 15 vegetable beds for residents and are distributed on an annual basis. One allotment is reserved for the children. Some

families grow most of their vegetables on the roof. Some raised beds are provided for disabled gardeners. The other two thirds of the roof garden are used as an open air meeting place for residents.

This 11 year old intensive green roof is a good example of a successful project, one of many in Vienna, where green roofs on new developments are now law (see Chapter 4.2). The social benefit of accessible communal roof gardens was one of the drivers for their promotion by the Vienna City Council.

One thing the architect (who is a resident) regrets is that they did not provide an integrated irrigation system. During the summer timed mains water sprinklers are activated during the night. He suggests drip irrigation systems be included in future projects. There is also no rainwater harvesting from the pitched roofs nor is grey water being re-used. The technology for this was not available at the time of construction. The roof over the staircase could also provide some runoff for storage and use on the green roof.

3.4 CASE STUDY 4

Rooftop allotments at One Brighton

At the time of writing this project is still at the design stage and therefore subject to modification. It is included here because it is the first of its kind in Brighton, where the author is resident. In this section of research, the developers agreed to answer a questionnaire on the development. This is reproduced in full in Appendix 11.4. Below are the key points that came out of the questionnaire and information obtained from the website (<http://www.bioregional-quintain.com/brighton.php>).

Blocks E and F at the New England development have been designed by Crest Nicholson BioRegional Quintain according to ten One Planet Living principles which aim at zero emissions, zero

waste, and include measures to support local and sustainable food.

A number of features that are located on the roofs will contribute to these aims: there will be areas of brown roof for biodiversity, 8 small scale wind turbines on both blocks, and an array of photovoltaic panels that will share the roof on Block E with 15 - 20 mini-allotments of approximately 1m² each. Some of these are planned to be in the form of raised beds for better accessibility, the others will be at floor level. One in nine apartments will have the opportunity to hire a mini-allotment on an annual basis and it remains to be seen how this is going to work out in terms of demand. The Residents Management Organisation will take care of their management.

Rainwater will be collected for use on the allotments, and kitchen waste will be collected from both blocks in a special in-vessel composter for use in the locality.

It will be interesting to conduct a post occupancy survey on the success of this development as a whole, and of the roof allotments in particular. At the present stage these are regarded more as a hobby than a necessity, but their provision, however small, is encouraging for the future.

3.5 CONCLUSIONS

The four case studies in this chapter demonstrate that the growing of edible plants on green roofs is already happening, or being planned on new developments.

Although they are isolated cases, the success of the accessible intensive green roofs at RISC, 'Sargfabrik' and Aspern Pharmacy show that for many of the concerns raised by policymakers (see Chapter 7.2 and Appendix 11.2 Table 5) solutions have already been found, tried and tested for a number of years. In view of future needs for locally grown food in urban areas it will be prudent to encourage their inclusion in new developments through policy.

4. EXISTING GREEN ROOF POLICIES IN SOME EUROPEAN COUNTRIES

In Austria, Switzerland and Germany planning policies regarding the greening of buildings in urban areas are issued by local authorities, while construction standards are imposed nationwide. Green roofs began to appear in some towns and cities in the 1970s and 1980s as an answer to problems with air pollution, storm water management and the urban heat island. High densities, sealed surfaces, emissions from industries and traffic, coupled with insufficient green spaces left on the ground drove planners and councillors to look for new solutions. The greening of roofs and walls offered a way forward, by increasing the area of planted surfaces where land was no longer available.

Manufacturers, construction firms and landscaping suppliers formed themselves into associations and offered advice to politicians, planners, developers and designers. In Europe such associations exist in Germany, Austria, Switzerland, The Netherlands, Italy, and Hungary; they are united under the umbrella of the 'European Federation of Green Roof Associations' (EFB) of which Livingroofs.org (UK) has recently become a member. They ensure that a high standard is maintained at all levels, from manufacture through execution to the maintenance of green roofs.

The 'Guidelines for the Planning, Execution and Maintenance of Green Roof Sites' (2002) that have been compiled by the German FLL (a research foundation for landscaping issues) have become the model for standards in most European countries. Colloquially known as the 'FLL', these guidelines set detailed standards for every aspect of green roofs.

The following are a few examples of towns and cities with clear green roof policies.

4.1 LINZ, AUSTRIA

Linz is an industrial town with 190,000 inhabitants, situated on the river Danube. It provides jobs for 190,000 people, 11,000 of which are in chemical and steel industries. The economic boom which started in the 1960s attracted a large number of industries that took over large sections of agricultural land that previously surrounded the town. A rapid deterioration of air quality ensued caused by industrial pollution combined with a reduction in green spaces (Maurer, 2006)

In 1985 the planning department of the municipality of Linz issued the first 'Green Space Plan for Linz' and compulsory regulations concerning the greening of new and existing buildings within the area were introduced.

The section on 'Greening' ('Begrünung') of the Municipal Planning Laws states that:

- New residential buildings and extensions >100m² where the roofs have a pitch <20° must have green roofs, except if the remaining ground that is maintained as green space amounts to 60% of the building plot.
- New industrial and commercial buildings >500m² where the roofs have a pitch <20° must have green roofs, except if the remaining ground that is maintained as green space amounts to 60% of the building plot.
- The green roofs are to have a min 15cm layer of vegetation and planting must cover 80% of the roof.
- The roofs of all subterranean buildings are to be greened. The uppermost layer must be 50cm vegetation and cover 80% of the roof area.
- The difference in levels between roofs over subterranean buildings and the adjacent ground must not exceed 60cm and the difference must be bevelled and covered with vegetation to give continuity.

- For each 500m² of built-on ground at least one tree of a large-crowned species must be planted on natural ground or an existing tree be preserved.
- A continuous green belt with trees and shrubs is to be provided on the 5m recess between road and building; in front of walls without window openings; and on inner courtyards.

EXCEPTIONS:

- On roofs with pitches >20° planting is not compulsory.
- The green belt may be interrupted to provide vehicular and pedestrian access or forecourts in front of entrances; the total area not covered with planting must be no greater than 50% of the front garden.
- Grass verges and ditches which form part of the rainwater drainage system must not be planted with trees or shrubs.

As a result of these and other planning laws, concerning emissions from industrial sites, the cloud of polluted air that once engulfed the city has long disappeared. In 1989, four years after the introduction of the law on 'greening', the city of Linz had 4,180m² of green roofs. An additional 404 green roofs were added since the introduction of subsidies in 1989, amounting to a total of 36,700m² of green roofs in 2005. Subsidies were granted for new as well as retrofitted green roofs and amounted to 13 to 25 Euros per m² of green roof and covered up to 30% of the cost of the superstructure. (Maurer, 2006)

Post-occupancy inspections revealed that intensive green roofs were much better maintained than extensive green roofs. This may be due to a misunderstanding of the meaning of low maintenance and to the fact that they are not accessible. Intensive green roofs on the other hand are in constant use and are tended either by professionals or by volunteers.

The success, according to Dr. Maurer (2006) was due to three factors: compulsory regulation; financial incentives; and information.

4.2 VIENNA, AUSTRIA

Of the 8.1 million inhabitants of Austria 1.6 million live in the capital, Vienna. The city has a number of large public parks and green spaces and the wider roads and ring roads are lined with trees. However, there are no private gardens in the densely built-up inner districts and until the advent of the Hundertwasser Haus nearly 23 years ago green roofs have not been heard of in Vienna.

In recent years the idea of green roofs has gained in popularity, notably in the residential sector, where green roofs are used as communal gardens by residents and community groups (see case study 3.3 'Sargfabrik'). Intensive green roofs have also gained in popularity with inner city companies who introduced them as a symbol of prestige.

The planning authority of the city of Vienna issued revised policies regarding the landscaping of certain sections of the town in 2006. Plandokument 7639 (December 2006) - issued by Magistrat der Stadt Wien, MA 21 B, Stadtteilplanung und Flächennutzung - states that:

- The roof structure above subterranean buildings must be able to carry a layer of 165cm of soil to secure the possibility for the planting of trees.
- Flat roofs that are >100m² and with a fall up to 5° are to be constructed as green roofs to the highest prevailing technical standards and the planting must cover at least 50% of the area of flat roof.
- In designated areas of the town where single storey extensions or annexes are added to existing taller buildings these must have flat roofs with max 5° fall and be executed as green roofs.
- The roofs over underground parking garages to be constructed to allow for a top layer of min 60cm for subsequent planting.

To raise awareness and to encourage the country-wide introduction of more green roofs the Austrian Association for the Greening of Buildings (Verein für Bauwerksbegrünung) together with the Ministry for the Environment recently organised a competition (2007-2008) inviting towns and parishes to compete for 'Town with best green roof policies, the highest number of green roofs and the most remarkable green roofs'. Local authorities are asked to declare if they provide grants for the construction of green roofs.

In Austria green roofs are promoted for providing:

- valuable habitats for animals and plants;
- recreational space for residents in high density areas;
- rainwater storage and an improved local microclimate;
- a porous, absorbent antidote to the sealed ground;
- mitigation of the urban heat island effect;
- cooling in summer and warmth in winter for the floor beneath the roof;
- extended roof life due to diminished temperature fluctuations;
- cleaner air by absorbing particulates and binding carbon.

An additional element in favour of green roofs that has not yet been given consideration in English speaking countries is that green roofs absorb up to 100% of the 'electrosmog' that is increasingly regarded as a serious health hazard. A study conducted by the University of Kassel, Germany, concluded that a vegetation layer in 15cm of light substrate attenuates 99.4% of mobile phone frequencies between 1.8 - 1.9 GHz. (Minke, 2001)

Cities such as Vienna and Linz provide grants for the retrofitting of green roofs. On average between 8 and 25 Euros per m² of green roof (up max 2 200 Euros) are handed out, depending on depth of vegetation layer.

4.3 BASEL, SWITZERLAND

In Switzerland all larger towns such as Zurich, Basel, Bern, Luzern and Schaffhausen as well as smaller parishes have green roof policies which state that all flat roofs are to be extensive green roofs.

In Basel green roofs have been introduced since the 1970s ...*"to help reduce stormwater runoff, provide summer cooling and thermal insulation in winter, and benefit nature conservation"*. (Brenneisen, 2005)

In 2002 Basel Canton passed a Building Law requiring *"all new roofs over 100m² to be green roofs"* (Brenneisen, 2005). The main drivers were the conservation of endangered species and the enhancement of biodiversity. The cost of an extensive green roof is negligibly higher than the cost of a traditional flat roof covered with shingle, and long term energy savings soon make up for the difference in cost. Therefore the new policy met with little opposition and has since been fully accepted. With planning permission expert advice is given on how to maximise the ecological properties of a specific green roof. (Brenneisen, 2007)

The number of green roofs has received a boost by government subsidies in 1996 and 2005. The main drivers for the first subsidy were energy conservation and the enhancement of biodiversity in the built environment. Funds were made available for new developments as well as for retrofitting green roofs on existing buildings in need of refurbishment.

The second subsidy, from 2005 to 2007, provides funds for green roofs and roof insulation on existing buildings. As a result of the various green roof campaigns already 20% of Basel's flat roofs were green roofs in 2005. (Brenneisen, 2005)

For a successful implementation of green roof policies it was found that close cooperation between planners, developers and experts is crucial.

4.4 GERMANY

All sixteen German Federal States have green roof policies in line with the Federal Nature Conservation Act but, as each municipality has sovereignty over local planning matters no precise data on policies are available. According to Hämmerle (2004) 15% of all roofs were green roofs in 2004.

Ngan (2004) quotes a survey conducted by the German green roofs association (FBB, 2004) who contacted all German cities with over 10,000 inhabitants. Of the 398 (27%) who responded 145 had mandatory green roof policies in their local development plans, 70 offered financial aid and 201 offered reduced surface water rates.

The strongest incentive for the building of green roofs is the resulting reduction in sewage fees, which is granted according to the stormwater runoff coefficient. Bonn is one example of a city with zero surface water charges for buildings with green roofs.

The research conducted by the University of Kassel that shows that 'electrosmog' is stopped from penetrating into spaces under green roofs is also given consideration in Germany and Austria. (Minke, 2001)

Ongoing research on green roofs at the Universities of Neubrandenburg, Kassel and others are quoted in support of green roofs in other countries, and the FLL 'Guidelines for the Planning, Execution and Upkeep of Green Roof Sites' serve as a model in many countries, including the UK and Canada.

4.5 CONCLUSIONS

The success of green roofs in Germany, Austria and Switzerland shows the importance of putting policies in place. A number of European cities have introduced planning laws that make it compulsory to have green or brown roofs on all new developments with flat roofs.

Campaigning by national associations of green roof manufacturers, designers and fitters helps to raise awareness and encourages competition.

The drivers for the introduction of policies in support of green roofs differ from place to place, depending on local needs. In Germany the main emphasis is on storm water attenuation. In Switzerland green roofs were introduced for their thermal quality with resulting reduced energy consumption, and for biodiversity. In Austria the main driver for the introduction and promotion of green roofs is air quality and enhanced 'Lebensraum'.

The first local authority to encourage green roofs by means of grants was the industrial city of Linz. Since then incentives for green roofs have been introduced in many cities with good results.

Where the provision of green roofs is mandatory, extensive green roofs prevail because they are less costly to construct, in less need of maintenance, and therefore more readily accepted. Intensive green roofs are mostly provided by choice, where they serve as accessible green spaces with special functions such as for recreation, education or cultivation.

Success can be expected through policy, incentives and information campaigns; these points will be highlighted in the policy proposed and tested by the author.

Following the European model it is hoped that green roofs will become the norm in all areas of high density in the UK, underpinned by government legislation regarding climate change and sustainability measures.

The following chapter explores the policies currently in force in the UK that can be used in favour of green roof policy, bearing in mind that green roofs for urban agriculture will have to form part of the broader spectrum of green roofs.

5. GREEN ROOF POLICIES IN THE UK?

The question heading this chapter prompted a search through government policies dealing with planning in the built environment for references in support of green roofs. It revealed that green roofs are mentioned occasionally in UK policies as part of the sustainability agenda. The general concern with **biodiversity** since the 1992 UN Earth Summit in Rio de Janeiro, and with **sustainable development** since the 2002 World Summit for Sustainable Development in Johannesburg prompted the authorities to introduce measures nationally and locally.

5.1 'THE MAYOR'S BIODIVERSITY STRATEGY: CONNECTING LONDON WITH NATURE' (2002)

The Mayor's Biodiversity Strategy for London recognises the need for people to live within not more than 10 minutes' walk of a green space. The chapter entitled 'Connecting people with nature' concludes with Policy No.5 (p.70) which states:

"The mayor will seek to ensure that opportunities are taken to green the built environment within development proposals... This is particularly important in areas deficient in open spaces and in areas of regeneration".

Green roofs are mentioned in connection with the creation of new habitats for biodiversity (p.47), the greening of new developments (p.48), improving energy efficiency of buildings (p.37), and as part of sustainable drainage techniques (p.58).

The document also contains statements regarding the benefits of **allotments** for community development (p.14), for peoples' health (p.28), for reducing food miles (p.29) and for their value in waste management through composting (p.34) in addition to biodiversity.

A Green Roof policy is at the consultation stage in London and is said to be ratified during 2008. (Gedge, 2007)

This is very encouraging in terms of the author's vision of roof gardens and in due course agriroofs becoming a reality where they are most needed.

5.2 THE CODE FOR SUSTAINABLE HOMES (CSH)

The CSH published by the Government in December 2006 does not specify green roofs as such. However, green roofs can help achieve some of the desired standards by contributing in a number of areas.

The CSH suggests as one of its 'optional' sustainability criteria the following provision for **surface water run-off**:

"The percentage peak time attenuation should provide as follows:

50% in low flooding risk areas

75% in medium flooding risk areas

100% in high flooding risk areas".

Studies carried out by the FLL (2008a) show that, depending on soil depth and type of planting, from 40% to 90% of average precipitations is absorbed by a green roof. Therefore intensive green roofs, which have greater absorption properties are ideally suited as part of Sustainable Drainage Systems in areas of high flood risk.

Green roofs contribute to the '**Ecological Enhancement**' of a building and will therefore score point under 'Ecological Criteria'

..."for minor or major enhancement" according to the CSH

..."where ecological features have been designed for positive enhancement in accordance with the recommendations of a suitably qualified ecologist."

The following is a summary of issues where scores can be gained by using green roofs:

- **Building fabric:** the heat-loss (and heat-gain) parameter:
see chapter 2.2 regarding thermal benefits of green roofs;
- **Reduction of surface water run-off** as described above;

- **Household recycling:** paper, cardboard and most kitchen waste can be composted for use on the green roof;
- **Construction waste:** crushed uncontaminated building waste can be used as an ingredient of the substrate (for an extensive brown roof it would be the main ingredient);
- **Composting facility** must be provided for an intensive green roof as it would be for a garden;
- **Sound insulation** the layers of soil and the planting provide better acoustic conditions especially for the spaces immediately under the roof;
- **Private space** an intensive green roof is an accessible outside space;
- **Ecological enhancement** by providing habitat for biodiversity;
- **Health and wellbeing** by providing outdoor recreation space;
- **Pollution** is reduced through the absorption of dust particulates by plants.

The CSH is voluntary for house builders at present but it is planned to become mandatory for the entire housing sector in future. Here is an opportunity to introduce accessible green roofs for use by residents nationwide.

5.3 PLANNING POLICY STATEMENTS (PPS) SUPPORTING THE GREENING OF THE BUILT ENVIRONMENT

A number of Planning Policy Statements issued on a national level give guidance on issues that will benefit from the inclusion of green roofs on all types of developments.

- **PPS1** (January 2005) 'Delivering Sustainable Development'
- **PPS9** (August 2005) 'Biodiversity and Geological Conservation'
- **PPS25** (December 2006) 'Development and Flood Risk'

5.4 SHEFFIELD GREEN ROOFS POLICY

Sheffield will be the first town in the UK with a clear, prescriptive green roof policy, to be included in 2008 in its Local Development Framework. It reads:

Green roofs will be required on all medium and larger developments, and encouraged on all other developments, provided they are compatible with other design and conservation considerations. The green roof must cover at least 80% of the total roof area.

This is the type of policy that has worked well in Linz, Vienna and other European cities and it is hoped that other Local Authorities will follow Sheffield's example.

5.5 CONCLUSIONS

As in most other European countries planning decisions about green roofs are made by Local Authorities in the UK, guided by national and regional guidelines issued by Central Government. The prevailing trend towards sustainable construction and biodiversity offers a favourable basis on which Local Authorities can introduce green roofs on a large scale on new developments. On these favourable premises, encouraged by the success of green roof policies in other countries, a policy proposal for the provision of green roofs for urban agriculture has been written and sent out for feed-back. It is aimed at inclusion in Local Development Frameworks.

6. TESTING A POLICY PROPOSAL FOR GREEN ROOFS FOR URBAN AGRICULTURE

The proposed policy with background notes and a questionnaire were addressed to a selection of 46 people, together with an introductory note about the associated thesis. Planners, policy makers (councillors/ politicians) and campaigners were the main target groups; in addition a few academics who work in related fields were approached for feed-back.

Five groups of respondents were targeted, because of their perceived influence on policy making:

- Local Authority Planners
- Local Councillors and London Assembly Members
- MPs, MEPs
- Campaigners
- Academics

Groups targeted	Q	A	'Yes'	'No'	Y/N	Remarks
			To policy proposal			
Planners	7	5	1	3	1	One "possibly"
Councillors + London Assembly Ms	17	7	5	2		Q sent to: 7 Green, 3 Lab, 3 Con, 4 Lib 'Yes' from 5 Green 'No' from 1 Lib and 1 Lab AM
MPs, MEPs	3	0				1 Lab, 2 Green
Campaigners	14	6	5		1	Transition Town, Green Roof; One "yes and no"
Academics	5	3	1	1	1	Lecturers, researchers one "possibly"
Total	46	21	12	6	3	45.7% responded

Tab.1

Breakdown of questionnaires (Q) sent and answers (A) received

Copies of the policy proposal, the accompanying background notes and the questionnaire are reproduced on the following three pages.

What is required to support the implementation of accessible green roofs for agriculture in the UK?

BACKGROUND FOR POLICY PROPOSAL

Present day food production, processing and distribution use large amounts of fossil fuel, a finite source that is slowly running out. As D.A. Pfeiffer wrote in 2003 *"In a very real sense we are literally eating fossil fuels"* [1]. In view of climate change and the proposed action plan to reduce greenhouse gas emissions by 60% by 2050 in the UK [2] food security will need to come under serious consideration in the near future.

Food shortages will hit the urban population hardest, if local food growing is not introduced in time. Governments will therefore do well to introduce measures that encourage local food production now.

The creation of suitable roof space on new developments for agricultural use, in conjunction with urban and peri-urban food production at ground level, where available, could provide locally grown food and bring a number of additional benefits. Experience in Havana, Cuba has shown that 50% of food can be grown locally, by traditional (organic) methods if all available suitable surfaces are used strategically.

The technology for intensive and semi-intensive green roofs that are required for food-growing already exists and has been used for over 20 years successfully in other countries. Although the initial cost would be higher than for extensive roofs, this would be compensated by other savings such as the attenuation of stormwater run-off and the reduction in energy use for cooling in summer due to the increased thermal mass.

These, in addition to all other social, environmental, economic and aesthetic benefits derived from the greening of buildings will contribute to the sustainability of our towns and cities. The new carbon emission targets can only be met if urban agriculture is given serious consideration. But first and foremost: food security will be assured.

[1] www.energybulletin.net/281.html

[2] Prime Minister's speech on the Environment, 19th November 2007

POLICY PROPOSAL

'To promote the construction of accessible flat roofs on all new developments and extensions to existing buildings over 100m², including the infrastructure needed for their use as urban agricultural space.

The roof superstructure must be executed to the highest technical and safety standards for intensive green roofs and with a vegetation layer depth of no less than 30cm.

In addition to encourage the retrofitting of roofs above existing subterranean buildings and above parking garages to be made available as intensive green roofs for urban agriculture.'

Incentives for developers are proposed as:

- Free technical advice on the construction of intensive green roofs;
- Grants per m² and type of green roof superstructure (e.g. from Central Government, Local Government or Water Authority);
- Increased sustainability ratings (e.g. for reduction of surface water run-off; use of construction waste in the substrate; sound insulation; reduced energy for cooling);
- Awards for sustainable construction;
- Reduced surface water rates for occupants proportionate to stormwater attenuation (as a selling point).

Benefits for municipalities (from all types of green roofs):

- Reduced energy consumption and associated carbon emissions due to reduced urban heat island effect;
- Reduced risk of flooding;
- Improved local climate;
- Pleasant and healthy environment in which to live / work.

Benefits for municipalities (from urban agriculture):

- Reduced traffic for food delivery / reduced food miles;
- Local composting for local use;
- Self-sufficiency from local food production;
- Educational facilities for schools and colleges;
- Job opportunities.

QUESTIONNAIRE

Can you support my proposal? Yes... No...

If 'Yes' please state why

If 'No' please state why

What, in your opinion, needs adding or changing?

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

If you would like your name and occupation to be quoted in my thesis, please write it here.

Please e-mail your responses by 10th December to hwaldbaum@onetel.com

Thank you for your time!

7. EVALUATION OF RESPONSES TO THE QUESTIONNAIRE ON THE 1ST POLICY DRAFT

7.1 ANALYSIS OF RESPONSES TO THE 1ST POLICY DRAFT

In all 21 (45.7%) people responded, 5 of these are Green Party councillors, 6 are campaigners involved in sustainability issues connected with Transition Towns, Green Roofs or Urban Agriculture (UA), 5 are local authority planners, 2 are London Assembly Members (1 Lib, 1 Lab), and 3 are academics (2 ecologists/ researchers, 1 planning development lecturer)

In all 12/21 (57.1%) are in favour of the proposed policy;

3/21 (14.3%) said "yes + no" or "possibly";

6/21 (28.6%) rejected the policy; these were 3 planners - one who required more detailed information "to be convinced", one who is for green roofs in principle but wants the agricultural reference removed and one who wants multi-functional green spaces; 1 ecologist / academic who is a green roof proponent but rejects the idea of large scale agricultural use; and 2 London Assembly Members, one Labour and one Liberal Democrat, both of whom thought that cost would outweigh benefits.

Those in favour were 5 green councillors and 5 environmental campaigners, 1 planner and 1 academic.

None of the Conservative politicians responded and no MP/MEP.

One can speculate that those who did not respond to the questionnaire either did not have time or were not sufficiently interested in the issue. The high proportion of respondents in favour of the policy can not be assumed to be representative of policymakers and stakeholders in general; due to lack of information and possibly lack of interest one can expect more opposition than support at this stage.

Indeed it is often opposition to an idea in its development which helps to make it stronger in its execution.

The comments received have been tabulated under three different headings for easy reference (see Appendix 11.2)

- Table 3. Positive responses in support of the policy;
- Table 4. Concerns expressed by respondents;
- Table 5. Additions and suggestions from respondents.

The number of positive responses received is encouraging, seeing that it is a relatively new idea. The unanimous support from Green Party councillors highlights the fact that if sustainability policies are already on the political agenda an additional green policy stands a good chance of being adopted:

- *"I'll incorporate it into the Kirklees LDF proposals"* (Cllr. Andrew Cooper, Kirklees);
- *"I think this work is ground breaking and as a Councillor elected in an inner city ward with the problems of poor health, increasing fuel costs and the need to tackle climate change this proposal is what I hope I could be pushing for."* (Cllr. Bernard Little, Sheffield)

In the same vein the 'nays' received from London Assembly Members belonging to parties with other priorities show that more work needs to be done to win them over.

It is evident from a study of all responses that more detailed information has to be presented to decision makers in support of a new idea. Both policy makers as well as planning officers need more information on tried and tested solutions in order to allay their concerns. More quantified evidence of benefits and quality assurances need to accompany the policy proposal, including references to documents such as, for example, the Building Standards that apply in other countries that have compulsory green roof policies.

There was also room for misinterpretation because urban agriculture was not clearly defined and it was suggested to use words like 'allotments' and 'market gardening' instead. The 2nd draft takes this as well as many other valid points into account.

Cllr. Jon Hooper (2007) pointed out in an e-mail that he "*would like a stronger policy which isn't afraid to "require"*", and that if words like "encourage" or "promote" are used, developers and planners won't take much notice. He suggested getting inspiration from the 'Merton Rule'.

Two high profile green roof experts (Dusty Gedge and Dr. Nigel Dunnett) who are both campaigning to introduce green roofs on a big scale are against roofs being used exclusively for agriculture.

- "*The policy should be for green roofs in general, with agriculture just one of the possible uses of green roofs.*"

..." *There are more sustainable uses for urban roof tops, and I think food production should be seen as just one option in a much wider mix of green roof types...*" (Dunnett, 2007)

- "*The use of roof agriculture needs to be part of and not exclusive to the whole sustainability agenda... Agricultural production should be one of the functions with the delivery of multifunctional ecosystems services approach.*" (Gedge, 2007)

Their campaigns propose lightweight, simple (extensive) green roofs or 'living roofs' that require only little maintenance once established, and are aimed at encouraging biodiversity. Their campaigns are supported by evidence of the success of green roofs in other countries, where they have been introduced over the past twenty years, such as in Germany, Austria and Switzerland.

In the UK green roof policies are just beginning to be introduced by some Local Authorities. Sheffield's and London's are expected to come into force in 2008. There is still some reluctance and opposition to their introduction, despite the documented benefits and advantages; resistance to change is often an inherent ingredient of the status quo.

Developers are reluctant to put in the extra capital unless they can recover it at the point of sale, which depends on market forces. At present the demand for intensive green roofs is more

likely to come from large companies such as the London Docklands Development Corporation who turned the roof of Canary Wharf tube station into a roof garden for the public. Extensive green roofs are more readily accepted because the expense that goes into them is compensated by savings on Sustainable Drainage Systems, and maintenance of the roof is minimal, once the vegetation is established.

The experience of Germany, Austria and Switzerland showed that the large-scale implementation of green roofs of any type can only be achieved through the introduction of policies and regulations. Once required by law they become the norm, but the tendency will be for minimum requirements to be met. Extensive green roofs, if properly maintained can contribute to energy savings due to their thermal properties. These can easily be measured in monetary terms.

Roofs used for agriculture also help reduce energy bills for heating and cooling and they absorb more stormwater due to greater depth of substrate, but their maintenance is more labour intensive and they also require a system of irrigation. There has to be a demand for them, such as in areas with no gardens and no allotments, where residents want to grow their own food. Housing estates in disadvantaged high-density urban areas are the obvious starting point.

At present intensive green roofs, with their costly structure and high maintenance requirements are only built at the request of individual clients. The need to provide the possibility to grow food within cities is not seen as imminent in the developed world. Yet, as was pointed out by Geoff Wilson (2006a) *"...more affluent nations also need urban agriculture for a better diet and life style"*.

At a recent meeting of the ABUNDANCE PROJECT in Brixton Duncan Law, the coordinator of Transition Town Brixton mentioned that twelve estates in the area have shown interest in this new urban agriculture project. Work on turning the space between buildings into allotments at the Guinness Trust Estate is about to begin on the ground. Roofs are also going to be

investigated for their suitability for food growing. This initiative comes from the grass roots, from people who live in the area who want allotment space.

It was pointed out by one respondent that at present not many people use their gardens for food growing, because it is cheap and convenient to buy fresh vegetables from the supermarket. This situation is bound to change as fuel prices escalate and cheap food can no longer be flown in from around the world. January 2008 saw the first \$100 oil barrel. Local farming will become the sustainable way to provide food again, reducing food miles, providing fresh produce without prolonged refrigeration and making the origin of produce traceable. GHG emissions will be reduced as a result and the health of the nation will be enhanced. The experience in Cuba has shown that diabetes and heart disease have decreased since the political situation forced the country to become self-sufficient in its food production. (Community Solutions, 2006)

The 'Background for the Policy Proposal' that accompanied the questionnaire gave the reason for the urgency to build agriroofs for when the need arises. The comments received demonstrate that the effect of peak oil on present day food production is not understood and that food security is not regarded as an imminent issue. The fact that "*In a very real sense we are literally eating fossil fuels*" (Pfeiffer, 2003) does not seem to be understood.

A study by McLaughlin (2000) calculated that the agricultural energy consumption in the US in 1994 was 400 gallons of oil per capita. This figure is unlikely to have diminished and the oil fields are beginning to run dry. 16% of the oil used in agriculture goes into the transportation of food alone.

By growing food locally food miles become negligible and carbon emissions are reduced to almost zero. This is a reason in itself to consider urban agriculture as a solution. Yet land is at a premium in cities and roofs are the obvious places where small scale food production can take place. When the need arises there will be a high demand for accessible roof space; this should be provided for in Local Development Frameworks in time.

Dunnett (2007) also objected to the wording of the proposal:

- "This is an unrealistic proposal, largely because of the way it is written. I support the basic idea behind the proposal, but the policy, as written, is counter-productive."

He added another point to consider when re-writing the policy proposal:

- "...that the use of the term Agriculture is also misleading. In reality, most roof spaces are relatively small-scale, and most existing examples of food production are quite specialised. I think that you are actually really looking at urban horticulture / market gardening type activities, rather than agriculture."

Dr. Stefan Brenneisen (2007) from the University of Zurich, the leading light in Swiss green roof issues, expressed similar doubts about large scale roof top agriculture, summing up that the energy and effort needed to grow food on roofs could prove to be so great that working on the ground remains the only feasible option. This is true, provided there is enough space near enough on the ground on which food can be grown, as is the case in Switzerland.

Both Gedge and Dunnett also express their concern at the requirement of intensive green roofs with 300mm substrate, because of the structural implications due to weight, resources and energy use in construction, hence higher embodied energy / higher ecological footprint. Therefore a comparison between the initial energy expended to put the intensive roof in place and that needed to import food into towns over a period of time will be useful further research.

Dunnett (2007) points out that

- "The Green Roof Policy in Sheffield...due to be ratified in June [2008]...will require green roofs to be constructed on all new medium and large scale developments in the city...The minimum depth that the policy requires is likely to be 70mm..."

These comments, coming from green roof proponents, will serve as guidance for the 2nd draft of the policy proposal. The term 'agriculture' as used in the proposal, may indeed be misleading in that it evokes images of large commercial fields, when in reality the focus of this thesis is on small scale community schemes or allotments for local schools and residents. The 2nd draft will have to be clear on that by including a definition of urban agriculture. Following on from this, the second point to be taken into account in the 2nd draft is to require a percentage of all green roofs to be made suitable for food growing, e.g. proportionate to the number of dwellings in residential areas, and on school roofs and only where land on the ground is not available for allotments.

The 1950 Allotment Act recommends the provision of four acres (16,187 m²) of allotment space per 1000 people by the local authority. This results in 4x4m=16m² area per head; a family of four would be entitled to 64 m² which is only $\frac{1}{4}$ of the traditional 250m² allotment size.

Taking Brighton and Hove as an example: at present all 2300 plots of 250m² each (575,000m² in total) are rented out. With a population of 247,817 (Census 2001) this allows 23m² per head yet it does not cover the demand, as the closed waiting list shows. This simple calculation demonstrates that supply often does not meet demand and with more land being sold off for residential development the situation will get worse. What better time than now, while many buildings are at the planning stage, to introduce roof allotments as an alternative? (See case study 'One Brighton' the only project so far, where this is being done; if this proves to be a success it is hoped that more of the kind will follow).

The idea of pay-back time as used when calculating other investments cannot be applied here, as the value of lives saved by providing food for survival in a crisis situation cannot be measured in monetary terms. This may seem an extreme scenario but the impacts of climate change and high fossil fuel prices are already being felt. Situations like this are common in developing

countries, where communities must rely on their own sufficiency. They are also not unknown in the developed north of the world, where people have suddenly had to provide a lot more food locally for themselves, such as during the 2nd World War.

Providing means for a local food supply can be compared with the inclusion of good quality lifeboats on a ship that is thought may never sink. If it does, or when it does, the lifeboats are worth the lives of the rescued people and this cannot be measured in terms of the capital that went into building the ship.

7.2 CONCERNS EXPRESSED BY RESPONDENTS

The concerns expressed in the responses can be grouped into six categories: (see Appendix 11.2 Tabulation of Responses)

1. Structural implications and cost
2. Water, leaks and drainage concerns
3. Health and safety concerns
4. Maintenance issues
5. Sustainability issues
6. Policy issues

These concerns and the author's response to them are given below. Consideration of these concerns will also inform the development of the 2nd Policy Draft.

7.2.1 Structural implications and cost

The single most often expressed concern (7/21) is about the additional weight and the cost implication to developers.

Tab.2 shows a comparison between a structure with a 'normal' roof and two options of a structure with an added intensive green roof with a maximum load of 500kg/m² as indicated in The Green Roof Pocket Guide (GRC, 2007).

The calculations give two options, demonstrating that it is more economical and also more sustainable to increase the concrete

slab thickness than to use more steel for additional reinforcement. Steel has an embodied energy of 24.0 MJ/kg compared with that of concrete which is 0.99 MJ/kg (ICE, 2006). The percentage of increase in live load imposed by an intensive green roof on a five storey residential building is 13% on average. On a five storey office block the increase would be 11.3%. (Waddingham, 2007)

ROOF TYPE	MEASUREMENTS	REMARKS
Normal condition		
Slab thickness	250mm	
Grid	7m x 7m	
Imposed load	0.75kN/m ²	
Intensive Green Roof condition	Option ONE	
Slab thickness	250mm	Concrete: no increase, as same slab thickness. Steel reinforcement: 80% increase in weight
Grid	7m x 7m	
Imposed load	5.0kN/ m ² (max*)	
Intensive Green Roof condition	Option TWO	
Slab thickness	300mm	Concrete: 20% increase in weight. Steel reinforcement: 30% increase in weight
Grid	7m x 7m	
Imposed load	5.0kN/ m ² (max*)	

*Figure taken from The Green Roof Pocket Guide
(Calculations supplied by Ian Waddingham of QED Structures)

Tab.2 Structural increase from the addition of an intensive green roof

In addition the cost for the intensive green roof superstructure has to be accounted for, which will depend on its complexity and can be expected to more than double the cost of a naked flat roof.

However, the *increase in cost* must be weighed against a number of savings, such as the one resulting from the absorbency of the substrate, causing substantial rainwater attenuation. This results in fewer outlets and smaller or no storm water attenuation tanks being needed where green roofs are placed on buildings. Green roofs have become an accepted part of SUDS in the UK. Intensive green roofs with typical substrate depths of 250- 500mm can reduce the run-off by an average of 70% pa (FLL, 2008a) and will slow down the flow of stormwater in heavy rain considerably (Chapter 2.2 Fig.6). The absorbency depends on the composition of substrate and its depth. As an example a substrate composed of recycled crushed brick, expanded clay shale and 25% composted pine bark (Bauder Intensive Substrate) stores ca. 45% of its volume in water, excluding the additional absorption by plants. To get a realistic picture expense and savings have to be considered together.

Concerns about *damage to the waterproofing*, (locating punctures, cost of fixing leaks, maintaining and renewing roofs and invalidated guarantees) expressed by 3/21 respondents, have been proved to be unfounded in the past. The roof membrane is protected from root damage and mechanical damage by a solid puncture-proof root barrier that is either placed on it or forms part of the waterproofing. The roof membrane is also protected from extreme temperature fluctuations and from ultra-violet radiation from the sun and is guaranteed for 25 years according to DIN 4095 (German Standards) but is expected to last 40 years (Hämmerle, no date). The Green Roof Pocket Guide (GRC, 2007, p.11) claims that the lifespan of the roof surface is increased "*...2 -3 fold and thereby saving money in the long term.*"

This of course remains to be seen, as none of the modern green roofs have been in place for longer than 22 years. The Hundertwasser Haus in Vienna, built in 1983-85 was the first to have intensive green roofs with trees and shrubs planted in 60cm substrate and are still intact.

All manuals emphasise that strict standards have to be adhered to in order to validate these guarantees. There is no evidence that any green roof, built to the required standards, has so far

had to be replaced; therefore no figures are available to quantify such a possibility.

Foot traffic does not pose any danger to the roof membrane as intensive green roofs are covered edge to edge with the same high standard of finishes, be it gravel, paving stones or planting.

Point loads will have to be carefully dealt with. Trees or containers can only be planted in designated areas, such as above columns and load bearing walls. Plans (including roof plans) must be made available to the owners and managers of all new buildings for health, safety and maintenance reasons. This should be included in the Home Information Pack (HIP) which has been introduced in 2007. In other European countries (e.g. Germany and Austria) building plans form part of ownership documents. This gives those responsible for the upkeep and management of a building access to all structural information as well as knowledge of the routing of services. At present this is not required in HIPs but should be included. Green roof policies need to include this requirement for health and safety reasons, whether access is only for occasional maintenance or for frequent use.

"*Expensive balustrades needed for safety on roof*" is an issue that applies to all accessible roofs for the safety of maintenance workers (Building Regulations, Part K2, 2006). In the case of roofs for urban agriculture balustrades would be replaced with tough fences or parapet walls. In new-build these details would be part of the initial design. Their financial impact would therefore not be felt in the same way as in retrofit situations, which are not the subject of this thesis.

7.2.2 Water, leaks and drainage concerns

Blocked drains will not happen if the green roof is properly maintained. Green roofs incorporate drainage details and filtering system that prevent blockages or build-up of silt. Planting is prevented from growing near gutters and outlets by filter fleeces and layers of gravel. Therefore *unsightly slurry* is also prevented from running down the walls of the building. Drains and outlets have to be checked regularly on all roofs, and

on green roofs inspections have to be done twice a year to ensure no blockages will occur. Roofing company Bauder, which give 25 year guarantees for green roofs installed by them, give clear instructions for the maintenance of green roofs. (Appendix 11.6)

Soil erosion must be prevented before planting is established and at any time when soil is exposed to the elements. The methods suggested for crop growing on roofs, such as permaculture and forest gardening (Chapter 2.4) avoid bare soil by using continuous ground cover for a number of reasons. One of these is to keep evaporation to a minimum, thus cutting down on the need for irrigation. This is therefore a management issue on which type of agriculture gardeners adopt.

The *intensive use of water* becomes unnecessary when precautions are taken. The RISC roof garden (Case study 3.1) survived the drought of 2003 and issued a leaflet with helpful tips which can be obtained from their website. Irrigation is done with a perforated pipe ('leaky pipe') system that runs between the plants and is activated at night only, when evaporation is low. Ground covering plants and mulches further prevent the soil from drying out. Intensive green roofs are also provided with reservoir boards under the drainage layer where some water collects during rainfall and irrigation.

Rainwater collection and grey water re-use are further options, so that mains water can be kept to a minimum or not used at all.

7.2.3. Health and safety concerns

Building Regulations (2006) Part K2 state that

"any roof to which people have access...shall be provided with barriers where it is necessary to protect people in or about the building from falling."

Other rules that apply are: Work at Height Regulations (2005), Management of Health and Safety at Work Regulations (1999) and Working on Roofs INDG284. Health and Safety Manuals have to be made available to all people responsible for any work on roofs.

Roofs exposed to extremely *windy conditions* will have to be provided with wind breaks and planted accordingly, as would be the case on wind swept land. High fences can be provided to avoid danger of planting falling from the roof.

Liability in case of accidents is a worry to landlords. Building control will only allow access to roofs if the requirements of the Building Regulations (Protection) Part K are met; and insurers will demand that the health and safety precautions are all in place. User groups will have to be supplied with manuals and must take responsibility for the proper use of the roof. This is common practice in other countries. Manuals are to form part of the 'Management Guidance' stated in the revised policy proposal.

Access to green roofs will vary depending on location and use (e.g. school, residence or larger scale urban farming) but in all cases there has to be a system in place that allows only the responsible use of the roof and therefore access would be controlled for safety and security reasons by those responsible for it.

The following concerns that were raised by respondents have been largely dealt with under 7.2.1-7.2.3 above and elsewhere in the thesis and will therefore only be listed for the sake of completeness.

7.2.4 Maintenance issues

- who would be using these roofs?
- would they actually be used?
- expert management is needed;
- need support and commitment from estate based tenants / residents;
- random tree growth, such as buddleia or sycamore;
- point loads (containers, trees) could cause structural damage;
- intensive roofs need high maintenance
- few human resources for community activities
- education needed (methods of food growing on roofs)

7.2.5 Sustainability issues

- more structural material means more embodied energy, i.e. a larger carbon footprint;
- high degree of input of nutrients and water not sustainable
- intensive water use

7.2.6 Policy issues

- unrealistic proposal;
- people not ready for the idea of food-growing on roofs;
- green roofs not only needed for agriculture;
- the agriculture reference should be removed;
- food security issues not expected in the UK;
- CO₂ reduction and biodiversity more important than food growing in cities;
- economically not viable;
- councils have no money for incentives;
- stronger wording needed;
- objections from leaseholders;
- benefits not quantified;
- more information needed (education and technical);
- successful examples needed
- argument not convincing.
- councils are short of money so can't give free advice or grants

Some objections from a London Assembly Member highlight the worrying fact that the issue of future food security is not being taken seriously and that the benefits of local food production are not being understood, although they were mentioned in conjunction with the proposed policy. The comments from one respondent were:

- *"Food security will be ...more of an issue in the Mediterranean areas, not in the UK";*
- *"It would fail an economic appraisal. Why carry out expensive small scale food production in cities when we have set aside lands in the country?"*
- *"...you should start by looking at the needs of the City first. CO₂ reduction plus a contribution to the Mayor's*

biodiversity action plan might make it have a better business case..."

The 'Mayor's Biodiversity Strategy' in fact contains a number of points that can be used as arguments in favour of green roofs for urban agriculture:

"Allotments are particularly important in many areas where people do not have access to private gardens... Gardening and growing one's own food provides very important contact with nature..."
(Livingstone, 2002a)

Regarding greening new developments it states:

"Wherever appropriate, new developments should include new and enhanced habitat or design (e.g. green roofs)..." (Livingstone, 2002b)

The role of green roofs in sustainable drainage systems is mentioned as well:

"Sustainable drainage techniques, such as permeable surfaces, storage ponds, green roofs, even water butts, will be one of the keys to managing long term flood risk."
(Livingstone, 2002c)

7.3 ADDITIONS AND SUGGESTIONS FROM RESPONDENTS

There was also advice from some respondents to be incorporated in the 'policy 2nd draft'. Most of these points have been dealt with in the thesis.

Benefits that were not mentioned and should be added when submitting the proposal:

- biodiversity
- low input (alongside 'organic')
- emphasis on productivity of urban agriculture
- social/psychological benefits

Training for trainers should be provided, so that these green roofs are used effectively, i.e. about low-input agriculture methods such as no-till (no-dig), intercropping (forest gardening), permaculture, etc. These are covered in Chapter 2.4.

Definitions explaining the difference between 'conventional green roofs' and 'farmed green roofs' to be included.

7.4 CONCLUSIONS

The responses show that more detailed information is needed for planners to feel satisfied. Policy makers will only produce policies if they can be convinced that the advantages outweigh the objections. This applies to all new ideas. Policy also comes about under pressure from government or from EU directives. In addition policy is influenced by campaigns organised by the people whose votes councillors depend on.

The feed-back was comprehensive and useful for the preparation of the second draft.

8. THE REVISED POLICY PROPOSAL

POLICY PROPOSAL (2nd Draft)

To require the construction of green roofs on all new developments and extensions to existing buildings with a footprint over 100m² to enable a plant cover of minimum 75% of the roof area.

In built-up areas where no garden space is available for communal or individual food growing (urban agriculture) within 10 minutes walk of residential buildings, schools and community centres, a proportion of suitable buildings including parking garages and subterranean buildings are expected to have intensive type green roofs that can be made accessible for that purpose.

Guidance for their management will have to be made available when these buildings are handed over to users, and must form part of Home Information Packs or any similar documents.

Definitions

Green roofs are any flat or sloping roofs that are purposely constructed for the creation of habitats for plants and wildlife by being covered with soil and other growing mediums and planting. Depending on their complexity they are generally divided into extensive, intensive or semi-intensive green roofs.

Intensive green roofs as required for food production need a minimum depth of 300mm of substrate on a range of layers that facilitate the filtering, storage and drainage of water, and prevent damage to the underlying roof membrane

Urban agriculture is the process of growing food crops from small scale allotment and market gardening to large scale agriculture within the perimeter of a city or town. This includes the use of walls and roofs of buildings as well as spaces at ground level.

Benefits

Documented benefits from green roofs:

- Reduced energy consumption /carbon emissions due to their thermal properties
- Reduced urban heat island effect
- Reduced risk of flooding due to absorption by substrate and plants
- Improved local climate
- Biodiversity and wildlife habitat
- Reduced electro-smog under the green roof
- Improved physical and mental health for residents
- A pleasant environment in which to live and work.

Predictable benefits from urban agriculture:

- Reduced traffic for food delivery /reduced food miles;
- Local composting for local use
- Self-sufficiency from local food production
- More control over growing methods
- Educational facilities for schools and colleges
- Recreational facilities
- Job opportunities
- Facilitation of closer community and neighbourhood

8.1 TESTING THE 2ND POLICY PROPOSAL

The second policy proposal was sent out to four people who have seen, and commented on, the first proposal and the background notes. These were: planning ecologist Lindsay McCallum (LM), academic Paul Collins (PC), campaigner Dusty Gedge (DG) and councillor Jon Hooper (JH).

The following suggestions were made:

- To clarify at what level of government the proposal is intended: local development frameworks (LDF) and associated documents such as supplementary planning documents (SPD) were suggested. (PC, JH, LM)

- To separate the policy into three numbered paragraphs. (PC)
- To allow more flexibility for a wider range of situations, such as replacement brown field habitat which tend to be sparsely vegetated. (LM)
- To provide a list of acceptable activities that the roof could be designed to accommodate, e.g. roof garden, wildlife habitat, recreational space, allotments/food production. (LM)
- Regarding guidance (LM):
 - The policy proposer to provide some guidance to people implementing the policy via a SPD.
 - The designer of the roof to provide detailed information on how to maintain / manage it as a condition attached to planning permissions.

8.2 CONCLUSIONS

The demand for agriroofs will come from the grassroots (the voters) and from individual clients (e.g. housing associations, schools, hotels, restaurants). Opposition from developers can be expected at first because of the additional work and cost for construction. Therefore the advantages and commercial viability must be quantified.

As the experience in towns and cities such as Linz and Vienna has shown, the wide scale implementation of green roofs of any type can only be ensured by the introduction of policies which 'require', i.e. compulsive policies or 'rules'.

In order to successfully implement green roofs for urban agriculture a number of things need to happen.

1. The population will demand them; this will happen by people being kept informed of what is truly happening in the world of food supplies, i.e. the waste, the chemicals, the un-traceability of

the origin of food and its journey, the food scares, the state of oil production, the foreseeable shortages, the consequences of dependency on others.

2. Policymakers and planners must be kept informed of the ongoing experimentation with alternative food production and the solutions coming from research. The advantages must be quantified and weighed against the input.

3. Policies have to be put in place, which 'require' rather than 'expect, encourage or promote'. Clear, unambiguous wording is needed, stating which buildings are eligible, and giving figures for minimum coverage with vegetation.

4. Tough manufacturing standards and building regulations regarding the execution of agriroofs and the safety of users must be in place when the policy becomes law. They must ensure that the minimum standards provide roofs that can be guaranteed to perform their function well for the lifetime of the building.

5. Planning decisions must take into account the recommendations of an approved ecologist.

6. Maintenance and management guidance for the agriroofs must be included with the planning application and become part of the HIP or equivalent documents that are handed to clients and to future users on completion.

7. Media campaigns must be organised, that inform the public of the advantages of having access to agriroofs, their correct use and how to avoid the pitfalls.

Taking all these comments into consideration the policy proposal has been revised to read as follows.

8.3 POLICY PROPOSAL (final draft)

POLICY PROPOSAL

1. To require through local authority planning control the construction of green roofs on all new developments and extensions to existing buildings with a footprint over 100m² to enable a plant cover of minimum 75% of the roof area.

1.1 The 75% minimum plant cover requirement need not apply where the provision of brown roofs as habitats for wildlife is deemed to take precedence over green roofs by the local planning ecologist.

1.2 All green roofs must be executed in accordance with the mandatory industrial standards and building regulations.

2. In built-up areas where no space is provided locally for urban agriculture at ground level within ten minutes walking distance from residential buildings, schools, community centres and restaurants the roofs of these buildings are required to be executed as accessible intensive green roofs and provided with the infrastructure needed for food production.

2.1 The provision of accessible intensive green roofs provides enough flexibility for a variety of uses as roof gardens, recreational or educational space and allotments. Depending on the intended use the emphasis must be on maximum vegetation and minimum hard surfaces. This will ensure that rainwater absorption is maximised and runoff is minimised regardless of their use.

2.2 The designer of the green roof is required to provide detailed information on how to maintain / manage it as a condition attached to planning permissions. This information

must form part of Home Information Packs or equivalent building ownership documents whenever the roof changes ownership.

3. Parking garages and subterranean buildings are required to be designed and constructed with intensive green roofs that can be made accessible as additional agricultural land for use as allotments, for commercial food production or as parkland, depending on local need.

9. CONCLUSIONS

This thesis has explored the arguments for and against green roofs for urban agriculture and the possibility for their inclusion in a green roof policy. It has shown that a planning policy encouraging agriroofs can attract support from planners and councillors on the basis of scientific evidence and forecast.

Based on previous experiences of crises anywhere in the world it can be calculated that one of the worst aspects of peak oil and climate change will be the threat to food security. In the UK the urban population is going to be hardest hit, if no space for food production is available within the perimeter of towns and cities. The Dig for Victory campaign during the 2nd World War showed that food production from gardens and allotments can be highly productive in terms of land use and feed the population well.

It is therefore important that space for agricultural use is provided in areas of high density. As land continues to be concreted over with roads and buildings, encouraging more people to migrate into towns, the obvious solution is to turn "*the most underused asset [that] is above our heads*" (Livingstone, 2005) into living, productive gardens.

Green roofs have been used throughout history as a protective cover in many parts of the world and it is not inconceivable that fruit and vegetables would have been grown on them, where climate and accessibility made it possible. The introduction of urban agriculture into modern day town planning is being heralded by forward thinking organisations such as RUAF, the Transition Network, City Farmer and other interested groups.

Intensive type accessible green roofs are ideally suited for the purpose of crop growing and there are examples where this is being done. Urban agriculture has been shown to have certain advantages at social and economic levels, reduced energy and pollution costs for food growing, and also a beneficial impact on the local environment, micro-climate and biodiversity. No-dig,

low input - high yield crop growing methods are ideally suited for agriroofs (Case studies 3.1. RISC and 3.3. Sargfabrik); low water usage, organic composting and recycling also feature strongly in this approach.

While countless new developments are to be constructed in the UK - the government's new Eco-Towns initiative, urban regeneration initiatives - now is the time to introduce green roofs on all residential, commercial and government buildings and make the maximum possible area available as agriroofs.

In order to make this happen, the body of evidence of the benefits from green roofs and from urban agriculture has to be presented to stakeholders and policy makers, and policies have to be introduced. At the same time high standards for materials and for the execution and maintenance of green roofs in general must be put in place. The FLL Guidelines can be used as a model for these.

The evidence of the benefits from green roofs is available from studies conducted in countries such as Germany, Australia and Canada. They all show that energy consumption for heating and cooling is reduced, that the urban heat island effect is diminished, that the air is cleaner, that rain water runoff is reduced and slowed down, in addition to enhancing biodiversity, and lifting people's spirits.

Policies have been shown to be effective in Austria, Germany and Switzerland where green roofs have been introduced on a large scale during the past 20 years. These can serve as models for the UK.

There are recommendations for green roofs in The Mayor's Biodiversity Strategy for London. The London Borough of Barking and Dagenham has published a Planning Advice Note (2005) that gives advice "*as to how we can have more green roofs in the borough*". It expects applicants to follow it, but it is not compulsory. Some local authorities mention them in their Local Development Framework or Supplementary Planning Document as a means to provide for biodiversity or as part of sustainable

drainage systems. However, Sheffield is the first UK town to “require” green roofs on all medium and large developments, and the only one so far, though Greater London is said to be following soon, with policy in consultation at the moment.

Urban agriculture is practiced by individuals and community groups in most UK towns and is encouraged by the Transition Town Network and allotment groups. The Allotment Act of 1950 is still in use, requiring local authorities to provide 4 acres per 1,000 people, but long waiting lists show that the demand far outstrips availability. Where can more allotment space be provided as towns expand and space on the ground becomes development land? Green roofs are the obvious answer.

Therefore action is needed: firstly to overcome the reluctance of developers to include them; and secondly to convince government bodies that there is a need for them and that therefore compulsory policies should be introduced. Campaigns such as the Green Roof Campaign and the local Transition Town campaigns for urban agriculture are steps in the right direction.

As part of the thesis a policy for the introduction of green roofs for urban agriculture was proposed and tested. The responses have highlighted that more detailed information is needed to overcome the reluctance to accept that agriroofs are a feasible solution for a future without oil. However, many of the respondents supported the principle of a policy for urban agriculture and some even stated that they would be actively working to implement it in their region.

The urgency of the global situation also needs to be reiterated, in order to convince planning policy makers and developers, as well as individuals, of the need for this kind of action.

It will become easier to introduce agriroofs as the idea of green roofs becomes generally accepted, a process that has already begun. It is hoped that by the time the effect of peak oil becomes more obvious and the demand for locally produced food becomes the norm, the concept of agriroofs will have been put into policy, accepted and implemented.

If action is taken now, the parallel public infrastructure for food production in our cities may be in place by the time food security and supply is the urgent subject it is threatening to become.

The next step will therefore be to design a strategy targeting three groups that together can make agriroofs a normal feature in every town:

- politicians, especially those in local government, who have the power to implement them through policy;
- developers who have the means to provide them, but need to be convinced there is a demand for them; and
- the general public - the grassroots - who, becoming aware of changes in the food supply chain, will require them.

This strategy needs to be consistent across all sectors, be easily understood and straightforward to implement. Above all, it needs to make sense to those it is aimed at, providing convincing arguments and a clear and simple means of meeting the strategy's aims.

9.1 FINAL REFLECTIONS

Proposing a policy is a complex task. Aiming to introduce something on the basis of scientific calculations and forecasts one needs to start by compiling all the available evidence in support of the proposal. This provides the background information for those who need to be lobbied.

The best advice on policy writing can be obtained from those who implement them. A dialogue with sympathetic councillors and planners helps with the shaping and rewording of the document.

The resulting policy which consists of a few concise paragraphs, if successfully implemented, has the power to bring positive change to the lives of a great number of people and to the landscape in which they live. This vision amply compensates for the amount of work, the hurdles and the pitfalls one encounters on the way.

10. LIMITATIONS AND RECOMMENDATIONS

For reasons of time and shortage of space a number of areas that are relevant to the debate on the feasibility of agriroofs could not be explored, and could therefore become the object of further research.

A survey on requests for allotment space among the urban population could help determine how much agriroof space would have to be provided to satisfy demand. A revision of the Allotment Act is overdue, seeing that demand for more allotment space is there already; how much more need will there be when local food growing will become not a pastime but a necessity?

An exploration of how policy making of the kind intended in this thesis actually happens in real life in a democratic society; what for example was needed to get the Merton Rule to be adopted by an increasing number of local governments? A similar approach may be needed to introduce an Agriroof Policy.

The full range of standards for the provision of safe and sound agriroofs in UK climates needs to be prepared, based on existing British Standards and Building Regulations and combined with standards that have been found effective in other countries with more experience in the greening of buildings. The same will be needed for the maintenance and management of agriroofs, to ensure their optimal performance.

Another area for further research is the retrofitting of agriroofs on existing flat roofs, many of which are standing bare at present but could potentially be vibrant, productive gardens. Research would need to focus on their potential and feasibility in terms of structural adjustments, accessibility and safety needs. But as the RISC roof garden showed, in many cases, this will certainly be within the realms of financial and practical possibility.

Research into the potential for other agricultural uses of roof area, such as animal farming and the range of new agricultural technologies mentioned in the section on sustainable growing methods would be interesting.

Estimating intangible benefits, the main one of which may be that people with access to roof gardens or other safe green spaces in urban areas may tend not to travel as often to escape their environment; this could be linked with a study comparing the embodied energy of a green roof versus environmental and health benefits.

Finally, awareness generally of the need to produce food closer to home needs to be developed. If towns and cities are not to be drastically affected, as supply chains are disrupted by rising oil prices and reduced food productivity levels, then a parallel infrastructure needs to be implemented in the near future to prepare for a time when food is less readily available on demand.

APPENDIX 11.1

LIST OF RESPONDENTS TO THE QUESTIONNAIRE

Initial	Full Name	Occupation	Category
AC	Andrew Cooper ☒	Green Party Cllr, Kirklees	Councillor/London Assembly Member
AW	Anne Wirstad	SolaRoof member and TT Brixton campaigner	Campaigners / Specialists
BB	Ben Brangwyn ☒	Transition Network co-founder	Campaigners / Specialists
BL	Bernard Little ☒	Green Party Cllr, Sheffield	Councillor/London Assembly Member
BW	Anon	Architect and Environmental activist	Campaigners / Specialists
CW	Anon	Planner, Council Ecology Line Manager	Planners
DG	Dusty Gedge ☒	Ecologist, Green Roof Specialist	Campaigners / Specialists ②
DR	Dave Richards	RISC Garden co-designer	Campaigners / Specialists
ET	Elizabeth Thomas	Senior Planning Officer and allotment gardener	Planners
JA	Janet Altry	Green Party politician, climate change campaigner	Campaigners / Specialists
JH	Jon Hooper ☒	Green Party Cllr, Torrington; on Planning Committee	Councillor/London Assembly Memb. ②
JL	Jon Lissimore ☒	Environment Manager, Lambeth Housing	Planners
LM	Lindsay McCulloch ☒	Planning Ecologist	Planners ②
MT	Michael Tuffrey	Politician, Lib Dem, London Assembly Member	Councillor/London Assembly Member
MW	Martin Whiteside	Green Party District Cllr, Stroud; Environm. Developmt	Councillor/London Assembly Member
ND	Nigel Dunnett	Ecologist, Horticulturist, Researcher	Academics
PC	Anon	University Lecturer	Academics ②
PO	Anon ☒	Planning Officer	Planners
RB	Robert Biel ☒	University Lecturer UCL Development Planning	Academics
VP	Vania Phitidis	Green Party District Cllr, Wealden	Councillor/London Assembly Member
VS	Anon	Politician, Labour, London Assembly Member	Councillor/London Assembly Member

Tab.3 List of respondents to the questionnaire (Anon names withheld; ② responded to 1st+ 2nd proposal; ☒ in appendix 11.3)

APPENDIX 11.2

TABULATION OF RESPONSES

Tab.4 Positive responses in support of policy	Respondent
"Helps reduce eco footprint of cities"	RB academic
"proposal suggests some practical measures" (for 'transition' from fossil fuel to self-reliance)	RB
Slowing down run-off	ET planner
Improving health	ET
"Raises awareness of agriculture to urban people"	ET
Increases urban shading	ET
Increases energy efficiency of homes	ET
"Gardens over underground car parks might be easier"	CW planner
"In principle as best practice approach to sustainable development"	JL planner
"It's good innovative thinking which simultaneously addresses many pressing issues"	JH councillor
"This makes complete sense. We need to be able to produce food in urban areas, and this would make a significant contribution"	Green councillor
"The policy is making (urban agriculture) possible by providing the infrastructure...when the need is there, it will be used"	Green councillor
"Sounds great - I'll incorporate it into Kirklees LDF proposals"	Andrew Cooper Green councillor Kirklees
"I think this work is ground breaking and as a councillor elected in an inner city ward ...this proposal is what I hope I could be pushing for"	Bernard Little Green councillor

Tab.4 Positive responses in support of policy (ctd...)	Respondent
"Because it is worth encouraging every possible way of reducing the impact of climate change and encouraging everyone to be as self-sufficient as possible in both food and energy"	JA campaigner
"Pretty comprehensive"	JA
"This looks like a sensible initiative - we're going to need to maximise all the available space possible for urban food production"	Ben Brangwyn Co-founder Transition. net
"It's crucial in order to build urban resilience"	
" A wonderful idea and a clear win-win strategy that makes perfect sense!"	AW campaigner
Food grown close to where it is consumed - low food miles	BW campaigner
Biodiversity increased in urban areas	BW campaigner
Pleasant to look at	BW campaigner
Holds (absorbs) water	BW campaigner
Moderates temperatures (reduces urban heat island effect)	BW campaigner
"The principle is right - using space for food production and recreation / creation of a pleasant environment"	MW gr cllr
"With peak oil already upon us & the need to reduce the energy embodied in our food, local organic food production is an important strategy to create a low carbon economy. Urban growing is one element in this & 'aerial allotments' an obvious solution to the reduction in suitable urban green space."	Dave Richards of RISC, garden designer
"A certain amount of roof space could be designated for this..."	DG ecologist
[Re:The retrofitting of roofs above existing subterranean buildings and above parking garages to be made available as intensive green roofs for urban agriculture] "This is fine"	ND academic

Tab.4 Positive responses in support of policy (ctd...)	Respondent
"...agricultural green roof policy could be a proportion of accessible roof space combined with those spaces needed for amenity and recreation."	DG ecologist
"All green roofs are becoming an accepted tool in the mitigation of climate change, which at present is the main concern...local food production would in itself help to tackle climate change"	Planning officer (PO)

Tab.5 Concerns expressed by respondents	Respondent	Solution proposed	Reference
1. STRUCTURAL IMPLICATIONS AND COST			
Cost implications to developers as stronger roof construction needed for additional weight	ET, JL, PO MT,MW,ND, DG	Capital savings from rainwater attenuation (fewer outlets + reduced stormwater sewerage as GR absorb + slow down run-off)	Chapter 7.2. and FLL
Random point loads if in loose containers	CW	Can be accounted for, must be fixed	StructEng
Locating punctures + cost of fixing leaks	CW ,BB	Root barrier prevents punctures	FLL, Bauder,
Liability in case of accidents. Owner or council should not be made responsible	AW	The food grower organisation must take responsibility and be insured	
Cost of maintaining and renewing roofs: seek 20 yr guarantee in UK	JL	High quality superstructure above high quality roofing doubles life of roof as protects it from UV rays + temperature fluctuations; Bauder gives 25yr guarantee	The Green Roof Guide
Guarantees invalidated if foot traffic between planters causes damage to roof membrane	JL	The green roof superstructure covers the roof edge to edge and includes footpaths	Glossary definition
Additional costs for new roof and re-roofing	JL	Applies only to retrofit before adding GR after which longer roof life guaranteed	
"Is this really achievable? 300mmm is a lot of weight"	DG	Structurally, yes	Structural Engineer

Tab.5 Concerns expressed by respondents	Respondent	Solution proposed	Reference
2. WATER, LEAKS + DRAINAGE CONCERNS			
Unplanted soil eroding, becoming sodden mud; running down side of building	ET,PO	A drainage layer (shingle) along margins ; Permaculture methods: soil is never bare	Case study3.3 Sargfabrik
Stuff blocking/clogging drains	ET,CW	Filter fleece and drainage layer prevent this	FLL
Someone puncturing the waterproof membrane	CW,BB	Root barrier protects roof membrane; no-dig methods must be taught + applied	Chapter : roof gardening methods
Intensive water use	MW,ND	Night time 'leaky pipe' irrigation if needed; reservoir board stores water	RISC case study 3.1.
3. HEALTH + SAFETY CONCERNS			
High vegetables (e.g Brussels sprouts) get wind blown , fly away, fall on pavement	ET	Protective fences; forest gardening; design for extreme weather conditions	Chapter 7
Ripped out vegetables caught by wind could fall on pedestrians below	ET	Adequate fences or parapets depending on location	Chapter 7
Health and safety: expensive balustrades needed	JL,BB,AW	These must be provided anyway for maintenance access on any flat roof	Part K Build. Regs.
Need to consider building regulations and health + safety in terms of design and access	PC	References to be included in final (3 rd) proposal	

Tab.5 Concerns expressed by respondents	Respondent	Solution proposed	Reference
4. MAINTENANCE ISSUES			
Random tree growth (eg buddleia, sycamore)	JL	Mandatory maintenance programmes and inspections required to prevent this	FBB/SRW (2005)
Few human resources available to promote community activity. Need support of estate based tenants and commitment from residents. Would space be actually used ?	JL, MT PO	Allotment association; involvement of local food growing enthusiasts , educational bodies	
"This type of agriculture in 300mm... will need serious maintenance."	DG	Allotment association; involvement of local food growing enthusiasts (TT), schools, etc	
With crop growing you get unplanted soil ("sodden mud") off season	ET, PO	Use permanent ground cover methods; this should be used on the ground too	Chapter 2.4.
Who will have control over the crops grown on roofs? (to justify that food security would be assured through urban agriculture)	PC	This is a misunderstanding as my statement (in the background to the proposal) refers to urban agriculture, not to agriroofs alone)	

Tab.5 Concerns expressed by respondents	Respondent	Solution proposed	Reference
5. SUSTAINABILITY ISSUES			
Weight issues: larger carbon footprint as foundations etc larger. More material = higher embodied energy	MW,ND	Point out /quantify offset by long-term advantages	Structural engineer
" ...[this] would require a significant steel upload with consequent carbon footprinting"	DG	Structural engineer to quantify extra embodied energy then compare with long term benefit when food is a priority	Structural engineer
Water issues: grey water used for irrigation is not available for toilet flushing	MW,ND	The technology is currently being developed in Germany	Talk by DG Hove, Dec 07
"The type of agriculture in 300mm will need a high degree of input [of] water and nutrients and need serious maintenance. Is this really sustainable?"	DG	Calculations needed	Further research
"Inappropriate use of resources; though [know of] concepts of large scale rice paddies and cherry orchards in China by McDonagh Architects"	DG	Get images as evidence in support of agriroofs	Further research 'Earth Pledge'

Tab.5 Concerns expressed by respondents	Respondent	Solution proposed	Reference
6. POLICY ISSUES			
Argument preceding proposal and detail of proposal not convincing. Need more education + technical information	CW,MT,MW	Re-writing of policy proposal; give more information in support of policy	2 nd draft of policy
No examples of successful food production on cultivated roofs given	CW	Include case studies as examples e.g. RISC and Sargfabrik	Case studies
No information on construction specifications, operation and maintenance implications + costing	CW	Book (thesis) needs to be made available to policy makers to support the proposal	Thesis chapters
Benefits not quantified (insulation, RW attenuation)	CW	Information in thesis text : studies quoted	Toronto
Objections from leaseholders to allow residents access to new or recent roofs	JL	The policy refers to new-build where accessibility of GR is part of lease	Definition of intensive
A stronger wording of policy that 'requires' is needed for a Local Development Framework	JH	Policy proposal rewritten	Final draft of policy
Councils are short of money so won't give 'free advice' on GR construction or grants	VP	This could change in future as happens in Germany and Austria	Chapters 4 + 5 on policies
"It would fail an economic appraisal. Why carry out expensive small scale food production in cities when we have set aside lands in the country ?"	VS (Lab AM)	Missing the point. Future food security depends on self-reliance as described in 'Background to Policy Proposal'	

Tab.5 Concerns expressed by respondents	Respondent	Solution proposed	Reference
6.(ctd) POLICY ISSUES			
Needs of city: CO ₂ reduction, Mayor's Biodiversity Strategy	VS	Reduced food miles = reduced CO ₂ Add biodiversity to list of benefits	2 nd draft of policy
"Food security issues will be ...more of an issue in Mediterranean areas not the UK"	VS	More education and information needed for policy makers	Caroline Lucas et al
The agriculture reference should be removed	PO	See definition of Urban Agriculture	Definitions
"...use of roof agriculture needs to be part of and not exclusive to the whole sustainability agenda"	DG	Rewrite policy as this is a valid point at this stage, but when food becomes an issue the attitude will change	Policy proposal 2 nd draft
"This is an unrealistic proposal, largely because of the way in which it is written. I support the basic ideas behind the proposal, but the policy, as written, is counter-productive."	ND	Re-write policy	Policy proposal 2 nd draft
"I wonder if the concept of people growing food on their roofs is one that can be readily accepted"	PO	Only a percentage of people will want to do this, unless circumstances force them to	Further research
"...it is not appropriate to reserve roof areas for one activity"	LM	UA to be only part of many uses	2 nd draft policy
"Intensive food production...on a commercial basis...people and wildlife are unlikely to be welcome"	LM	Policy to make clear it's about small scale community projects and allotments	2nd draft Policy

Tab.6 Additions and suggestions	Respondent	Notes
Point out low-input high-productivity urban agriculture	RB Academic	Supporting evidence
Methods: No-till, intercrop = permaculture, forest gardens	RB	
Link up with global movement 'Cities feeding people' RUAF	RB	
Put more emphasis on water management than food production ...that would be the best way to sell to planners	AC Councillor	
Emphasis on growing fuel prices and health implications as well as the need to tackle climate change and improve the quality of peoples' lives	BL Councillor	
Add biodiversity to list of benefits	Lab AM,DG	
Clarify that Havana, not whole of Cuba, grew 50% of food required within city boundaries of the town	BB Campaigner	
Mention legislation: by 2016 all new-built homes to be zero-carbon in use	BB ,JH Cllr	
The target of 60% (CO ₂ reduction) needs to be hammered at all opportunities	BB	
Anything that encourages the greening of the built environment and urban agriculture / horticulture should be supported	BW Campaigner	
Point out social and psychological benefits	MW	
Need to be designed for extreme weather conditions	ET	Add to policy
High protective fences	ET	
Listing of suitable plants	BB Campaigner	Appendix to policy
Permanently planted margins to avoid soil erosion	ET	Disagree; use pebbles instead

Tab.6 Additions and suggestions	Respondent	Notes
How 'farming ' would be organised	VP Cllr	Maintenance + management
Say who would be using the roofs	VP	
Responsibility for those on the roof not to be that of the owner or council but of an organisation that takes care of food growing	AW Campaigner	
Training the trainers in urban agriculture= create infrastructure to maintain roofs	RB	Part of final policy /education /management
A supported approach to this topic is needed, i.e. education	PO Planner	
Split policy into bullet points and add references to Building Regs and standards	PC	
A stronger wording for the policy is needed	JH	Write 2 nd draft policy proposal
Use the "form" functionality in Word to write policy	BB	
Policy needs more work, more technical information re weight, water and access.	MW Cllr	
Explain difference between conventional GR and farmed GR	RB	Use in thesis text
Container planting to avoid soil erosion	ET planner	
Crushed rubble substrate instead of soluble chalk for calcareous flora to avoid clogging drains	ET	
Herbs more tolerant of exposure than vegetables	ET	
How easy is it to move from one roof to another?	VP	
Food growing as one of a number of acceptable activities on green roofs and walls; need to ensure green infrastructure is multi-functional	LMc	
SolaRoof as an alternative to open air growing for higher efficiency production	AW	Further research

APPENDIX 11.3

A SELECTION OF COMPLETED QUESTIONNAIRES

Response from Cllr. Andrew Cooper (AC)
(26 November 2007)

Here's one reply Hanna, from Green Councillor in Kirklees
Vania

From: Cllr Andrew Cooper
Sent: 26 November 2007 17:38
Subject: Re: MSc thesis on Green Roofs for Urban Agriculture

QUESTIONNAIRE

Can you support my proposal? **Yes**

If 'Yes' please state why

Sounds great - I'll incorporate it into the Kirklees LDF proposals

What, in your opinion, needs adding or changing?

All looks good - the emphasis should be more on water management than food production I think. Not that I am against food production on roofs.

I do it on the flat roof outside my office - tomatoes and carrots. Its just that I think that would be the best way to sell it to planners

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

Politician - Green Party Councillor

If you would like your name and occupation to be quoted in my thesis, please write it here.

No problem with that

QUESTIONNAIRE

Response from Ben Brangwyn (BB)

(28 November 2007)

Can you support my proposal? Yes...*yes*.... No.....

If 'Yes' please state why

this looks like a sensible initiative - we're going to need to maximise all the available space possible for urban food production.

What, in your opinion, needs adding or changing?

Safety concerns on high buildings. Notes about leaking of flat roofs (a perennial problem). Types of suitable plants could be noted. The Cuba note isn't complete - they grew 50% of required volume of vegetables within the city boundaries of Havana (may have included fruit). Could mention the 2012(?) legislation concerning zero carbon new builds. Use the word resilience. (you could have produced this document using the "form" functionality in Word - check out the helpfiles and select the "form" toolbar to have a play. The target of 60% needs to be hammered at all opportunities - it's too little, it's got no "volume under the curve" considerations, it's a travesty and there's plenty of literature to back these assertions up.

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

It's crucial in order to build urban resilience.

Ben Brangwyn, co-founder, Transition Network.

From **Cllr Bernard Little (BL)**, Sheffield received 27.11.07

From: Bernard Little
Sent: 27 November 2007 15:13
Subject: Re: MSc thesis on Green Roofs for Urban Agriculture

Thank you for giving me the chance to feed back my perspective on your thesis.

Good luck for the future.

Cllr. Bernard Little

__*QUESTIONNAIRE*__

Can you support my proposal? Yes

If 'Yes' please state why:

I think this work is ground breaking and as a Councillor elected in an inner city ward with the problems of poor health, increasing fuel costs and the need to tackle climate change this proposal is the what I hope I could be pushing for.

If 'No' please state why

What, in your opinion, needs adding or changing?

Emphasis on growing fuel prices and health implications as well as the need to tackle climate change and improve the quality of peoples lives.

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

I am a local green councillor in Sheffield with a remit to look at improving the quality of life for a lot of people in the city centre.

QUESTIONNAIRE
Response from Dusty Gedge (DG)
(6 December 2007)

Can you support my proposal? Yes and No.....

If 'Yes' please state why

A certain amount of new roof space could be designated for this but would require a significant steel upload with consequent carbon footprinting

If 'No' please state why

The use of roof agriculture needs to be part of and not exclusive to the whole sustainability agenda.

Amenity/nature conservation. A blanket policy solely based on agriculture is not inclusive. It could quite easily be that agricultural green roof policy could be a proportion of accessible roof space combined with those spaces needed for amenity and recreation.

Agricultural production should be one of the functions with the delivery of the multifunctional ecosystem services approach

What, in your opinion, needs adding or changing?

See above

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local

government, policy maker, developer, politician,
ecologist, researcher, campaigner or other)

As an ecologist and a green roof specialist there are a
number of issues here:

- Room for biodiversity
- Is this really achievable 300mm is a lot of weight
- The type of agriculture in 300mm will need a high degree of input water and nutrients and need serious maintenance. Is this really sustainable?

If you would like your name and occupation to be quoted
in my thesis, please write it here.

Don't mind if my name is used.

QUESTIONNAIRE

Response from Cllr. Jon Hooper (JH)
(29 November 2007)

Can you support my proposal? **Yes**

If 'Yes' please state why

It's good innovative thinking which simultaneously addresses many pressing issues.

What, in your opinion, needs adding or changing?

Policies which say "encourage" or "promote" can often amount to very little, as developers and planners are resistant to change. I would like a stronger policy which isn't afraid to "require".

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

I'm a Green Party Town Councillor in Torrington, Devon, and on the planning committee my aim is to make sustainability a core issue - even though no one else is interested!

If you would like your name and occupation to be quoted in my thesis, please write it here.

Cllr Jon Hooper

Two e-mails from Jon Hooper, Councillor in Torrington, North Devon in response to my 2nd policy proposal

Sent: 14 December 2007
To: Hanna Waldbaum
Subject: RE: Green Roofs for Urban Agriculture

Hi Hanna,

it reads well to me, particularly the list of benefits, though you may get some people asking "what's the catch?" as there are no disadvantages listed. In practice I'm sure developers will try and argue that green roofs would be too expensive to build, so some accompanying background evidence of the costs of green roofs would be useful in practice.

It might be worth checking the wording of your definition of Green Roofs against other sources e.g. http://en.wikipedia.org/wiki/Green_roofs

The first sentence of your policy proposal is the sort of good, clear planning policy which I can imagine being enforced on all new developments. Your second sentence reads more like an "aim" for the local planning authority - something they'd include in the introductory documents to their Local Development Framework, and it would need to be backed up by a specific policy which could be applied to individual planning applications (such as your first sentence).

I hope that all makes sense.

Cheers,

Jon

Sent: 15 December 2007
To: Hanna Waldbaum
Subject: RE: Green Roofs for Urban Agriculture

A rough idea of the extra costs involved would be very interesting, yes. Maybe a quote from an authoritative report or case study? You wouldn't need it written into the policy proposal, but as background information - costs would be something which planning officers, developers and councillors would be quick to ask about.

QUESTIONNAIRE

Response from Jon Lissimore (JL)
(27 November 2007)

Can you support my proposal? Yes...**x**... No.....

If 'Yes' please state why

I support this in principle as a best practice approach to sustainable development. In practice I have a number of serious concerns- please see below

What, in your opinion, needs adding?

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

I am Environment Manger for housing and Planning in Lambeth. We manage approx 35,000 homes. My comments on your proposals are;

Roofs- food growing – serious obstacles

1. Health and safety

As a social landlord we have health and safety obligations that are onerous. Generally access to roofs is only allowed for residents as a specific means of escape (MOE) where designed into the building. In recent years we have had to install expensive balustrades on flat roofs just to cover Health and safety requirements to protect operatives who may only access the roofs when a repair or a maintenance issue occurs, even where there is no MOE.

2. Protecting public investments

We spend large amounts of public money maintaining and renewing roofs. When we renew flat roofs we seek 20 year guarantees via high quality propriety roofing systems to ensure longevity and value for money. Locating planters and having foot traffic on a roof surface could damage the roofing membrane and invalidate our guarantees. We have a statutory obligation to consult leaseholders on all capital

works and would not be able to recharge elements deemed as improvements. Leaseholders may well object to Local authorities proposing to allow residents access to a new or recent flat roof to grow food that a leaseholder has just paid £1,000s towards. Planters would need to be specified to ensure that if untended, random tree growth ie Buddleia / Sycamores did not penetrate the roof membranes causing leaks, disrepair, legal claims from tenants and leaseholders etc

3 Additional costs for new roofs and re-roofing

The proposals will have significant capital and revenue cost impacts as structural reinforcement will be needed on renewal of existing flat roofs and the build cost for new roofs would increase to accommodate extra loadings, access, balustrading for safety etc

4. Human resource / community implications

Local authorities have few human resources to promote community activity. Assuming a local authority supported growing food on roofs, they would need to ensure the estate based Tenants and residents groups supported the food growing proposals. The food growing group would need to have dialogue and agree with the landlord and the Tenants and residents group how the roof space would be safely managed .Proposals would need to address keeping the spaces well used, not become overgrown etc and need commitment from the residents involved

If you would like your name and occupation to be quoted in my thesis, please write it here.

Jon Lissimore
Environment Manager
Lambeth Housing

QUESTIONNAIRE

Response from Lindsay McCulloch (LM)
(10 December 2007)

Can you support my proposal? Yes..... No...X....

If 'No' please state why

As use of land within cities intensifies it is not appropriate to reserve roof areas for one activity. These areas will need to fulfil a range of roles, including open space and biodiversity mitigation, if a decent quality of life is to be maintained. In addition, these other activities are equally capable of providing the environmental benefits attributed to food production.

Intensive food production as proposed would need to be run on a commercial basis and, as with other commercial food production, people and wildlife are unlikely to be welcome. It may be more appropriate to use roof space as additional allotment land which would provide opportunities for social and recreational activity as well as food production.

What, in your opinion, needs adding or changing?

Provision for food production needs to be considered as one of a number of acceptable activities to be encouraged on green roofs and walls.

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

As an ecologist working within land use planning my point of view, as expressed above, is based on the need to ensure that green infrastructure, including green roofs, is multi-functional.

If you would like your name and occupation to be quoted in my thesis, please write it here.

I am happy for my name and occupation to be quoted if required:

-

Lindsay McCulloch
Planning Ecologist

QUESTIONNAIRE

Response from a Planning Officer (PO)
(7 December 2007)

Can you support my proposal? No

If 'No' please state why

I'm not sure that promoting the roof as an agricultural feature is the right approach.

What, in your opinion, needs adding or changing?

I think that the agricultural reference should be removed, I am unsure of national planning policy that promotes this specifically at present.

I think that the technical details should be for an SPD or simply an external standard referred to in the policy.

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

Local government planning policy officer. While I understand the approach suggested in this document I wonder if the concept of people growing food on their roofs is one that can be readily accepted at present. I would suggest that for the time being, standards should be developed that are compatible with this target in mind, after all green roofs are becoming an accepted tool in the mitigation of climate change, which at present is the main concern... I do understand that local food production would in itself help to tackle climate change. Also, will there be a structural issue with the extra weight imposed on the roof? Would this significantly alter construction methods?

I wonder if there is the potential for overloading people's minds on this subject, it is difficult for them to know what to believe and what approach to adopt when there is a seeming plethora of information and advice.

Additionally, while we could go around installing allotments on people's roofs, I wonder how many people actually use their existing gardens to grow their own food? I think that there would probably need to be a supported approach to this topic i.e. education etc. or a lot of effort could end up wasted. The roofs will need to be tended to ensure that food is grown, will there be people willing to do this, and compromise, for example, their leisure time?

I also wonder if water retention as an advantage of green roofs will be compromised by the crops grown on them? As I understand it sedum is used because of its various qualities. 1) Could the crops replicate these qualities? 2) What happens when the crops have been harvested? Does the roof simply become sodden mud?

Basically, I suppose what I'm saying is that the principle is okay, but as ever, issues would need to be addressed before implementation.

If you would like your name and occupation to be quoted in my thesis, please write it here.

QUESTIONNAIRE

Response from Robert Biel (RB)

(26 November 2007)

Can you support my proposal? Yes.....YES. No.....

If 'Yes' please state why

Helps to reduce ecological footprint of cities.

If 'No' please state why

What, in your opinion, needs adding or changing?

Place more emphasis on criterion of low input, alongside that of being organic.

Development of high productivity UA is a major qualitative change, the significance of which must not be underestimated. In my observation, current UA in this country mainly emphasises the cultural benefits in combatting alienation etc., and places very little emphasis on productivity.

A significant injection of knowledge is therefore very important.

The technique for high-productivity and low-input UA exists, i.e. no-till agriculture, intercropping, agroforestry etc., but a major programme is required to train trainers. There's no point just building the roofs, without creating the knowledge infrastructure to maintain them.

The link with the global movement co-ordinated by RUAF (Cities Feeding People) could be emphasised.

I would emphasise biodiversity among the benefits. For the benefit of a non-green roof specialist like me, I feel you should explain a bit more about the difference between conventional green roof (which as I understand it is planted from the standpoint of being low maintenance - maybe I'm wrong?) and a *farmed* green roof.

Please give a short description of your point of view regarding the proposed policy (e.g. as planner in local government, policy maker, developer, politician, ecologist, researcher, campaigner or other)

I'm interested in international political economy of sustainable development. Globalisation is fundamentally unsustainable because premised on continued availability of cheap fossil fuels. That's the problem. The solution is greater self-reliance including development of *capacity*. The primary issue therefore becomes *transition* between where we are now and where we want to get to. The proposal is great because it suggests some practical measures. At the same time, I feel the solution can't simply be engineered from the top. Because of the need to develop capacity, we have to find a way to work *with* communities, for example participatory planning.

If you would like your name and occupation to be quoted in my thesis, please write it here.

Robert Biel
Lecturer, University College London Development
Planning Unit

APPENDIX 11.4

'ONE BRIGHTON' CASE STUDY QUESTIONNAIRE

Case study questionnaire

Name of object

One Brighton

Sketch, reduced drawing or other image of the roof if available, showing arrangement of allotments

Not available at this time

Dimensions or area of roof

130 square meters approximately.

Above which floor is it situated?

Block E

Number of mini- allotments provided

Between 15 and 20

Dimensions of allotments (length, width, height if raised) including depth of substrate and soil

1 square meter approximately. Allotments are at floor level (although design is still progressing and there is a possibility of having some of them raised for disabled users.)

The materials used in the construction and build-up of a mini allotment

To be confirmed

What will the walkable roof surface be covered with?

There will be corridors of about 0.8 - 1.0 meters between rows of allotments

How does the number of allotments provided relate to the number of flats they serve?

1 allotment for every 9 apartments

Are they only accessible for residents of the block they are on?

Allotments will be hired on an annual basis by residents of One Brighton. They will be managed by the Residents Management Organisation.

Is there any provision for rainwater harvesting or a mains water hydrant?

Yes. Rainwater will be harvested from some of the roofs; collected in a bespoke system (compliant with health and safety regulations) and the water will be used to water the allotments.

Will any grey water be used on the roof or elsewhere in the block?

No. A grey water recycling system could not be justified (technically, environmentally and financially)

Are there composting facilities on the roof?

No. There is an in-vessel composter located in front of block F. All kitchen / organic waste will be composted and used as required within the development, including the mini-allotments. The remaining might be sent out for use elsewhere.

Will there be any solar panels or wind turbines on the same roof or on the other roof?

Yes. There is an array of photovoltaic panels on top of Block E and 8 small-scale wind turbines on the roof-top of Blocks E & F.

Any other sustainable feature on any of the two roofs?

Yes. There are brown roofs in some areas of Blocks E & F. Brown roofs contribute significantly to biodiversity enhancement and control of heat island effect.

Please also indicate if I have permission to use any images you may include and how I should credit or reference them.

The images that can be used are the ones on the website showing the development [<http://www.bioregional-quintain.com/brighton.php>]

Credit as follows:

Developer: Crest Nicholson BioRegional Quintain
Architect: Feilden Clegg Bradley Studios
Image: Design Hive

NOTE: Please note that design work is still in progress and the above answers reflect the design and specification up to this date (14 November 2007). The developer reserves the right of modifying both design and specifications without previous notice.

APPENDIX 11.5

RISC - THE EMERGENCE OF AN EDIBLE ROOF GARDEN

Plan of the roof garden at RISC

Yellow and brown = Hard path & Woodchip path

Dark green = Raised beds, herbs and annuals

Light green = forest garden, fruiting trees, shrubs and climbers.

Lighter brown = Wooden deck

Greenhouse, top right

Blue square = water tanks and

solar/ wind energy system, pumping dripline irrigation system



Fig.11 RISC - Plan of the Edible Roof Garden
(Source: www.risc.org.uk)



Fig.12 RISC: The leaky roof ... could this become a garden?
(Courtesy Dave Richards)



Fig.13 Replacing the skylights and laying stirling board
(Courtesy Dave Richards)



Fig.14 Refelting

(Courtesy Dave Richards)



Fig.15 Laying the first soil

(Courtesy Dave Richards)



Fig.16 Laying the stone path

(Courtesy Dave Richards)



Fig.17 Planting a forest garden on the roof
(Courtesy Dave Richards)



Fig.18 Weaving planters around the skylights (Courtesy D. Richards)



Fig.19 RISC roof garden planters and rainwater collectors
(Courtesy Dave Richards)



Fig.20 RISC roof composting (Courtesy Dave Richards)



Fig.21 Yes, we are on a roof!

(Source: The Author)



Fig.22 RISC Roof Garden: wildlife accommodation
(Source: The Author)

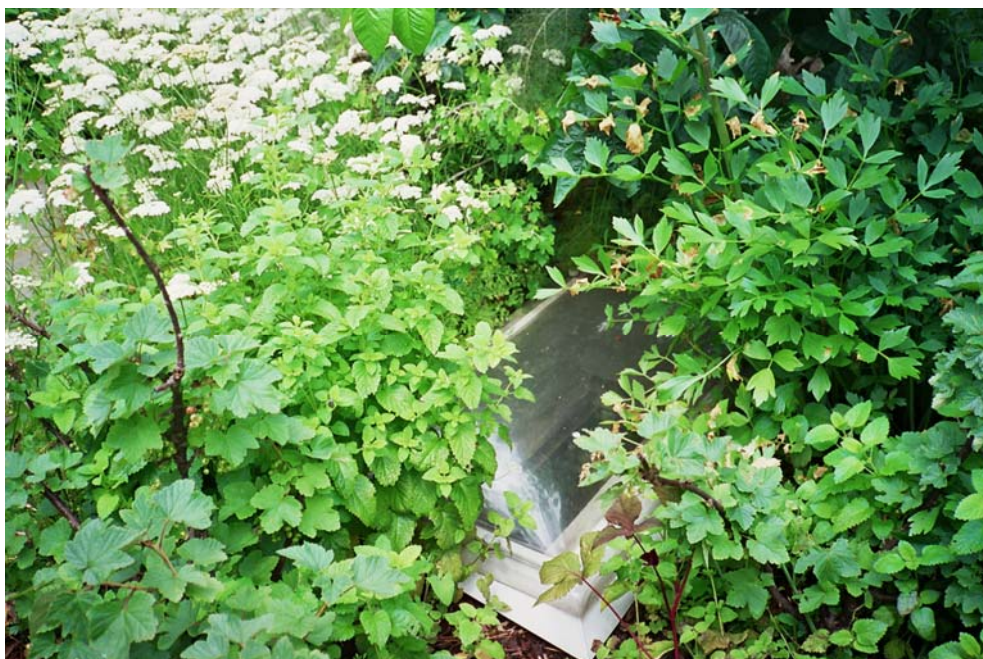


Fig.23 A healthy looking roof light (Source: The Author)

APPENDIX 11.6

BAUDER - MAINTENANCE PROCEDURE FOR INTENSIVE GREEN ROOFS



MAINTENANCE PROCEDURE

BAUDER INTENSIVE GREEN ROOF SYSTEMS

The following procedures should be carried out at twice yearly intervals (Spring and Autumn) in order to ensure that the roof is maintained in first class condition, and that any potential problems are identified at an early stage.

- 1 Clear all debris from the roof surface, rainwater outlets, chutes, gutters, etc. Debris must be removed from the roof and not simply flushed down rainwater pipes.
- 2 Ensure all rainwater pipes are free from blockages and that water flows freely through them.
- 3 Ensure any protective metal flashings or termination bars remain securely fixed and in place.
- 4 Examine all mastic sealant and mortar for signs of degradation, and repair/replace as necessary.
- 5 Where promenade tiles or pavers are in use, ensure that they remain in position, secure and in good condition.
- 6 Ensure that any items of plant/equipment, which may have been introduced to the roof are sited on a suitable slab, and that any fixings that may have been used to secure them do not penetrate the waterproofing. Please contact Bauder for advice regarding suitability of slabs.
- 7 Report any signs of damage or degradation to Bauder immediately, so that arrangements can be made for remedial work to be carried out if necessary. It is recommended that a roof plan marked with co-ordinates be used to record the findings of the inspection. This will avoid confusion and provide an on-going record of roof performance, for year on year comparison.
- 8 Works to adjoining areas - When carrying out maintenance to adjoining areas care must be taken not to damage the system. For example, any solvent based product allowed to wash down into the system will seriously de-stabilise the molecular structure of the bitumen causing it to fail. If this thought to be likely, then Bauder should be contacted so that they may advise. Chemical damage will invalidate the guarantee.
- 9 Vegetation barriers - These should be inspected annually. Any planting that has encroached into the vegetation barrier should be removed. If settlement of the barrier has occurred then additional washed stone, grade 20-40mm, should be added.
- 10 Cultivation of soil - The soil may be cultivated in the same way as any normal garden situation. However, care must be taken not to mechanically damage the system as this would invalidate the guarantee. The use of fertilizers / weed killers will have no detrimental affect on the system.
- 11 Alterations - Any alterations to the system that may affect the installation of the system will invalidate the guarantee. If such a situation should arise then Bauder should be contacted so that they may advise on the alteration and how it should be incorporated without affecting the guarantee.

IMPORTANT NOTE

In the event of any query arising, which it is thought may affect the system, Bauder should be contacted at the following address. The manufacturer cannot be held responsible for any failure due to use outside those parameters for which system is designed.

Bauder Ltd
Broughton House, Broughton Road, Ipswich, Suffolk IP1 3QR England
T: +44 (0)1473 257671 F: +44 (0)1473 230761 E: technical@bauder.co.uk
www.bauder.co.uk

(Supplied by Bauder Ltd.)

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